Winter 11-18-2011

Building Low-carbon Cities Through Local Land Use Planning: Towards an Appropriate Urban Development Model for Sustainability

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BUILDING LOW-CARBON CITIES THROUGH LOCAL LAND USE PLANNING: TOWARDS AN APPROPRIATE URBAN DEVELOPMENT MODEL FOR SUSTAINABILITY

By

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A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Community and Regional Planning

Major: Community and Regional Planning

Under the Supervision of Professor Zhenghong Tang

Lincoln, Nebraska

November, 2011

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University of Nebraska, 2011

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"The blunt truth about the politics of climate change is that no country will want to sacrifice its economy in order to meet this challenge. If we can deal with this in the right way and have this informal mechanism then I think we can find a way of meeting what I believe is the clear desire of our people - which is to find a way of combining rising living standards with the responsibility to protect our environment."

-- Tony Blair, Former British Prime Minister

The main purpose of this thesis is to study how to establish low carbon, attractive cities for human beings. This paper attempts to contribute to sustainable development by encouraging the development of low-carbon cities through local land use decisions. The study proposes to answer the following two research questions: 1) how well do the fastest growing cities in the U.S. implement low-carbon principles in their local comprehensive land use plans?, and 2) how can local land use plans be improved to

achieve the goal of low-carbon cities? Through evaluating the local land use comprehensive plans of the top fifty fastest growing population cities in the U.S., findings for improving low carbon cities planning are identified. Results show that while these cities have been able to establish effective planning frameworks, they have failed to incorporate low-carbon city principles into their planning frameworks. Cities can improve their local plan quality by enhancing the factual basis of the plans, adopting more specific goals and policies, and expanding the planners' toolbox to achieve low-carbon city planning.

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ACKNOWLEDGMENTS

I would first like to sincerely thank my advisor, Dr. Zhenghong Tang, for his guidance, support and encouragement during my master's studies. My research has benefited greatly from his enthusiasm, patience, and depth and breadth of knowledge. His valuable suggestions and feedback contributed greatly to my master's thesis.

I would also like to thank my master's committee members, Prof. Gordon Scholz and Dr. Yunwoo Nam for their support. They have been always friendly and provided professional feedback on my master's work. I thank Eileen E. Bergt and Emily Casper in the University of Nebraska – Lincoln Landscape Services department for giving me a great opportunity to work with them. My sincere thanks also go to Deborah Ball Derrick for her professional English review and grammar improvement of my thesis.

My family has been a continuous source of support and encouragement throughout my graduate studies. I thank my child, Benjamin Shi, for his lovely and cute smile. Finally, I would like to thank my husband, Jiangfan Shi. His love, support and encouragement have made it possible for me to reach the goal of earning the Master of Community and Regional Planning degree at the University of Nebraska – Lincoln.

ABBREVIATIONS

APA	American Planning Association
CCP	Cities for Climate Protection
CFC	Chlorofluorocarbon
CIP	Capital Improvement Program
EC	European Commission
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ICLEI	International Council for Local Environmental Initiatives
LEED	Leadership in Energy and Environmental Design
IPCC	United Nations Intergovernmental Panel on Climate Change
LA21	*Local Agenda 21*
NGRS	National Greenhouse Response Strategies
NAAQS	National Ambient Air Quality Standards
NOAA	National Oceanic and Atmospheric Administration
R & D	Research and Development
TDM	Transportation Demand Management
TOD	Transit Oriented Development
UK	United Kingdom
UN	United Nations
UNCED	United Nations Commission on Environment and Development

UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
WCED	World Commission on Environment and Development

Chapter One:

Introduction

Rapid changes in climate in the last few decades have caused many concerns. The global average temperature has increased by 0.4 ºC to 0.8ºC in the 20th century, and is projected to rise by 1.4 ºC to 5.8ºC by the year 2100 (Pani and Mukhopadhyay, 2010). Although there have been fluctuations between cold and hot periods over the long history of planet Earth, these fluctuations have usually occurred over centuries. The pace of changes has never been as rapid as it has been in the past few years. On January 12, 2011, the National Oceanic and Atmospheric Administration (NOAA) reported that the year 2010 equaled 2005 as the Earth's warmest year on record in the past 131 years (NOAA, 2011). The five warmest years since the late 1880s, according to scientists, are the years 2010, 2005, 1998, 2002, and 2003. Arguably, the earth's climate is changing already and will continue to do so in the future. The only question is how fast and how severe the effects will be. In 2007, the fourth report of the United Nations Intergovernmental Panel on Climate Change (IPCC) stated that increasing global climate change is mainly caused by human activities (IPCC, 2007c). In addition, the report states that human-induced climate change not only increases the global average temperature, but also leads to a rise in the sea level, ice fields melting at alarming rates, changes in wind patterns, and so on. The scientific evidence is compelling and overwhelming:

climate change is a serious and urgent threat and demands strong action to make the necessary changes to reduce the impacts on ecosystems, societies and economies.

The climate change issue affects the basic elements of people's lives, such as access to water, health and food (Stern, 2007). For instance, if the sea level rises one meter, it would flood 17 percent of Bangladesh's land mass and threaten coastal cities such as London and New York (APA, 2008); as a result, hundreds of millions of people could experience food and water shortages, as well as homelessness. Broadly speaking, climate change has significant impacts on ecosystems, societies and economies. From an ecosystem perspective, the IPCC model shows that an increasing risk of extreme weather events will occur with global temperature increases (IPCC, 2007b). For example, while Europe experiences an increase in inland floods, Africa is expected to see more droughts in arid and semi-arid land areas. Climate change can undermine social welfare and equity, in particular, for the most vulnerable groups who are already suffering from poor health or water shortages caused by the impact of climate change. Low-income groups have few or no resources to move to safer areas, insure their properties, and so on. An economic model developed by Stern (2007) estimates that the overall costs for climate change will be equal to losing 5 percent of global Gross Domestic Product (GDP) each year. If a wider range of impacts is taken into account, the damage could be as much as 20 percent of GDP (Stern, 2007). Thus, climate change impacts are significant on ecosystems, societies and economies, and how their sub-systems interact and shape prospects for sustainable development.

Evidence from the IPCC shows that increased carbon-based energy consumption and the resulting increase in greenhouse gas emissions is the primary cause of global warming and climate change. Reversing this trend requires an urgent shift toward to low-carbon development. Any delays will make the problem more difficult and costly to solve. Hence, the concept of building low-carbon cities will be introduced in this paper, as well as design strategies to make global and regional development more sustainable and livable. Since the climate change problem is part of the larger challenge of sustainable development (IPCC, 2001, Page 4), this thesis attempts to explore a possible way to meet this challenge. A clear vision and strategies for low-carbon city development will be illustrated, and a low-carbon land-use planning model will be introduced and discussed.

Section 1.1: The General Scientific Findings of Climate Change

Understanding the definition and key scientific findings of climate change is an essential starting point for acknowledging that climate change is indeed a threat. According to the IPCC, the term of "climate change" refers to "any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC 2001, Page 21). However, the United Nations Framework Convention on Climate Change (UNFCCC), Article 1, defines "climate change" specifically as "attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed

over comparable time periods." Climate change, expressed in terms of an increase in Earth's surface temperature, is caused by boosts in atmospheric concentrations of greenhouse gases (GHG), including carbon dioxide (CO2), methane (CH4), Chlorofluorocarbons (CFCs) and Nitrous oxide (N2O). One reason for climate change is that the majority of heating energy from the ground cannot pass into the atmosphere due to greenhouse gases, which stay in the atmosphere and get emitted back to the ground, thus increasing a warming effect. The largest part of GHG emissions is composed of carbon dioxide, which is well accepted as the warming effect of greenhouse gases. Carbon dioxide accounts for 89 percent of total GHG emissions in the U.S. and 72 percent of GHG emissions around the world (Figure 1.1). Apparently, the equivalent concentration (in ppm) of carbon dioxide in the atmosphere is the crux of the climate change challenge as well as low-carbon city development.

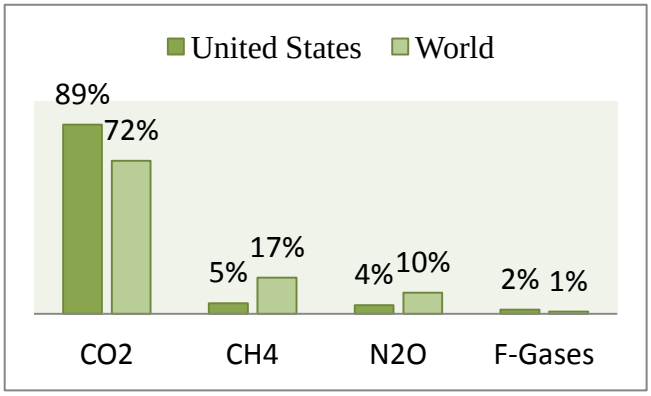

Figure 1.1: U.S. and World GHG Emission Profile by Gas 2005
Source: WRI, CAIT – US (2007)

The following are general scientific findings which establish that there is indeed an urgent and serious threat of the impacts of climate change:

Finding 1: The scientific evidence indicates that warming of the earth largely due to human-induced GHG emissions has increased since pre-industrial times, with an increase of 70 percent between 1970 and 2004.

In 2008, the concentration level of GHG was about 430 parts per million (ppm). However, before the Industrial Revolution, the GHG level in the atmosphere was 280ppm. According to the IPCC's Fourth Assessment Report (2007c), between 1970 and 1974, global GHG emissions grew by 70 percent, due primarily to human activities. The largest growth came from the energy supply sector (+145%). Other sectors responsible for growth in GHG emissions include transportation (+120%) and industry (+65%), as well as changes in land use (+40%).

Finding 2: Evidence from most countries and coastal regions shows that Earth's ecosystem is already being affected by climate change, and is particularly evident in global warming.

The IPCC claims that the mean temperature of the earth increased 0.6ºC during the last century (Houghton et al., 2002). This warming has been linked to various observed changes in our ecosystem. They include: 1) The sea level rose 0.1-0.2 meters over the last 60 years, while during this same time period, there has been a 10 percent decrease in snow cover. 2) Wind patterns are changing. The hurricane season of 2005, especially Hurricane Katrina, was more severe because of the warmer ocean temperature. (3) Regional rainfall patterns are changing; there are more frequent and severe droughts in parts of Africa and Asia (Houghton et al., 2002).

Finding 3: Some impacts of climate change may be slow to appear, but the effects are lasting and will continue to grow over the next few decades.

The evidence shows that even if greenhouse gas emissions are stable, anthropogenic warming will continue for years because of the timescales associated with atmosphere flow processes and feedbacks (APA, 2008). If concentrations of GHG and aerosols could be held at year 2000 levels, the IPCC estimates that a 0.2ºC warming would still be expected over the next 20 years.

Some people argue that there is no sufficient evidence to indicate that climate change is rapid and unexpected; they believe that changes will be gradual and within control. On the other hand, the IPCC warns that large-scale and high-impact changes in global and regional climate system are to be expected, and there is the possibility of unpredictable alterations to the climate system (Grubb, 1999). According to the IPCC's estimation, if the temperature increases more than 2ºC degrees, up to one-third the species on Earth could be at risk for extinction. If the sea level continues to rise, the world's land mass would disappear over several centuries. Therefore, it is time to think about how to deal with the climate change issue. A possible answer will be found in Chapter Three of this thesis.

Section 1.2: Cities and Climate Change

Studies show that population and economic growth are the major driving forces behind increasing CO2 emissions worldwide over the last two decades (Pani and Mukhopadhyay, 2010). Cities have more than half the world's population right now. Over the last century, cities have become a significant locus for human activity. In 1900, only 15 percent of world's people lived in cities; today, more than half of the world's population – 3.2 billion people – lives and works in urban areas. According to the U.N.'s projection, by 2030, 60 percent of the world population, or 4.9 billion

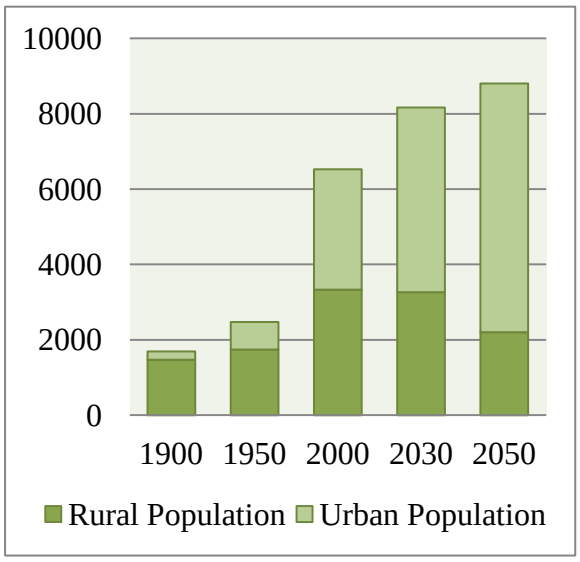

Figure 1.2: Urban and Rural Population Projection of the World (Millions)

Source: "World Urbanization Prospects: The 2005 Revision, Pop. Division, Department of Economic and Social Affairs, UN". http://www.un.org/esa/population/publications/WUP2005/2005wup.htm.

people, will live in urban areas. By 2050, there will be 70 percent of the entire global population living in cities (Figure 1.2). Cities provide opportunities, benefits and approximately 75 percent of economic growth, while cities also are responsible for more than 70 percent of overall carbon emissions. Cities are consuming 75 percent of the world's energy and causing at least 75 percent of pollution worldwide

at the same time (Girardet, 2008). They are the places where most industrial goods are produced and consumed, where the majority of fossil fuels for manufacturing are burned, and where innumerable problems result from such activities, such as urban heat islands, over-population, traffic problems, and energy shortages. Hence, the former Director General of the United Nations Environment Program (UNEP), Professor Klaus Topfer, stated that: “The battle for sustainable development, for delivering a more environmentally stable, just and healthier world, is going to be largely won and lost in our cities” (UNEP, 2005).

It is obvious that as man-made products, cities are the major destroyer of the ecosystem on the planet (Rogers, 2000). However, cities are a significant frontline in the fight against climate change. There are four related reasons (Bulkeley and Betsill, 2003). First, as mentioned above, cities have a high consumption of energy and production of waste. However, a city has jurisdiction over development activities and direct control of municipal energy operations and waste management methods. It can contain and control energy supply and management, transportation systems, land-use planning patterns, building codes, waste management, and policy decisions. Second, local governments have already engaged with issues of human impact on the environment and have attempted to translate from global efforts into local practice through Local Agenda 21 (LA21) and Local Action 21. These actions have profound implications on the mitigation of climate change. Third, following the second reason’s point, it is argued that local governments can facilitate action by others to address climate change issues. On the one hand, local authorities can

develop practical small-scale demonstration projects that show the costs and benefits of controlling GHG emissions. On the other hand, local authorities can urge state and federal governments to enact policies to meet the GHG emission reduction targets. Finally, local governments have considerable experience in addressing climate change impacts within the fields of energy management, transport and planning, and many have direct control over emissions resulting from municipal operations.

The significance of local action was highlighted in the Brundtland Report in 1987 and the Rio Conference in 1992. After then, city sustainability was widely adopted in global sustainable development strategies. Satterthwaire (1997) argues that in order for cities to achieve sustainable development, their "environmental performance … has to improve not only in terms of improved environmental quality within their boundaries, but also in terms of reducing the transfer of environmental costs to other people, other ecosystems or into the future." Under this statement, addressing the climate change issue should be a key component of cities' sustainability.

Section 1.3: The Importance of Building Low-carbon Cities

Studies show that increases in human-induced GHG emissions are due primarily to burning of fossil fuels and land-use changes (IPCC, 2007a). Moreover, there is a growing acceptance by scientists and policy makers that land use planning

and development strategies can lead to reductions in fuel consumption. For example, a compact city form can reduce travel demands to decrease fossil fuel consumption, and mixed-use development can reduce energy consumption. Therefore, planning professionals have the opportunity and obligation to deal with climate change issues in land use planning practices and processes. It is urgent and necessary to develop functional and aesthetically enjoyable spaces while ensuring low CO2 emissions. In this paper, a low-carbon city model is developed to achieve the realization of sustainable development by reducing carbon emissions. Since most decisions about land use are made at the local level – by public officers, local planners, stakeholders and citizens in cities, counties, metropolitan organizations, and special service districts – local land use planning plays an important role in mediating the impacts of climate change (Tang, Hussey, and Wei, 2009). This paper aims primarily to explore and develop a low-carbon city model through local land use planning to achieve the goal of sustainable development. Figure 1.3 shows the relationship between local land use change and climate change at local and global levels.

Indeed, more and more local authorities have realized that global climate change has a critical “local dimension” (Betsill, 2001). Local efforts have profound implications on reducing global greenhouse gas emissions. Local jurisdictions can influence development and activities to address climate change issues. Therefore, local land use plans can address the causes, driving forces, impacts and responses of climate change in the following ways:

Information power —…educate, persuade, coordinate, encourage participation and consensus, and offer a vision of the future

Regulatory power —…use tools of zoning, subdivision regulations, building codes, sanitation codes, design standards, growth boundaries, wetland and floodplain regulations

Spending power —…use CIP and budget arrangement

Taxing power —…special taxing districts and preferential assessment for agriculture and open-space uses

Acquisition power —…. purchase development rights, conservation easements

Coordination power — …coordinate with multiple agencies

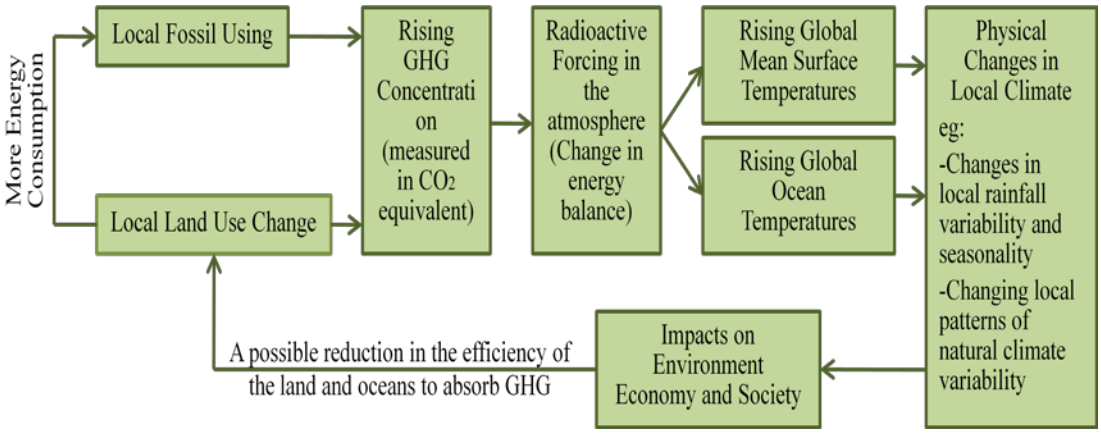

Figure 1.3: The Link between GHG emission and Land Use Change

Source: Stern, N. (2007). The economics of climate change: The Stern Review. Figure 1.4 at page 8. Cambridge, UK: Cambridge University Press.

Local land use planning can address climate change through two basic approaches: mitigation and adaptation (IPCC, 2007a; APA, 2008; Davoudi et al., 2009; Tang, Hussey, and Wei, 2009). Mitigation and adaptation efforts and investments will have large impacts on opportunities to achieve lower carbon levels in the next couple of decades (APA, 2008). The IPCC defines mitigation as "anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases" and adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007b, Page 869). Mitigation means avoiding the adverse impacts of climate change by acting directly or indirectly in the long term. Adaptation means adjusting land use activities and practices to reduce unavoidable impacts in the short and medium term. There are strong relationships between mitigation and adaptation, although they contain different planning tools. Indeed, priorities in planning have become the focus of debates.

However, most researchers believe that adaptation and mitigation are two sides of the same coin. A balanced, complementary approach should be established to respond to climate change; together, they can significantly reduce the risks of climate change (APA, 2008). If global mitigation approaches are not effective, local adaptation approaches are impossible to establish. If local mitigation approaches do not exist, global mitigation is unfeasible; if local adaptation is not appropriate, local mitigation has the potential to be undermined. Jeff Howard (2009) advocated for

three key principles of adaptation and mitigation priorities: 1) Mitigation has priority, 2) Mitigation is the primary form of adaptation, and 3) Effective local adaptation requires a long-term global perspective. Strategies towards low-carbon cities in this thesis are based on these approaches.

The IPCC claimed that the risk of dangerous, global-scale impacts of climate change would rise dramatically if warming exceeds 2°C of the pre-industrial level (3.6°F above preindustrial levels, or 2.2°F above today's levels). The Stern Review (Stern, 2007) summarized potential changes based on current scientific literature (Figure 1.4). Fortunately, we can still avoid this temperature threshold through building low-carbon cities. The present worldwide economic crisis presents an opportunity to make a transition from a carbon-based society to low-carbon society. It is a vital time in the history of planet Earth. The sooner we address this issue, the better. As former President John F. Kennedy said, " It is our task in our time and in our generation, to hand down undiminished to those who come after us, as was handed down to us by those who went before, the natural wealth and beauty which is ours."

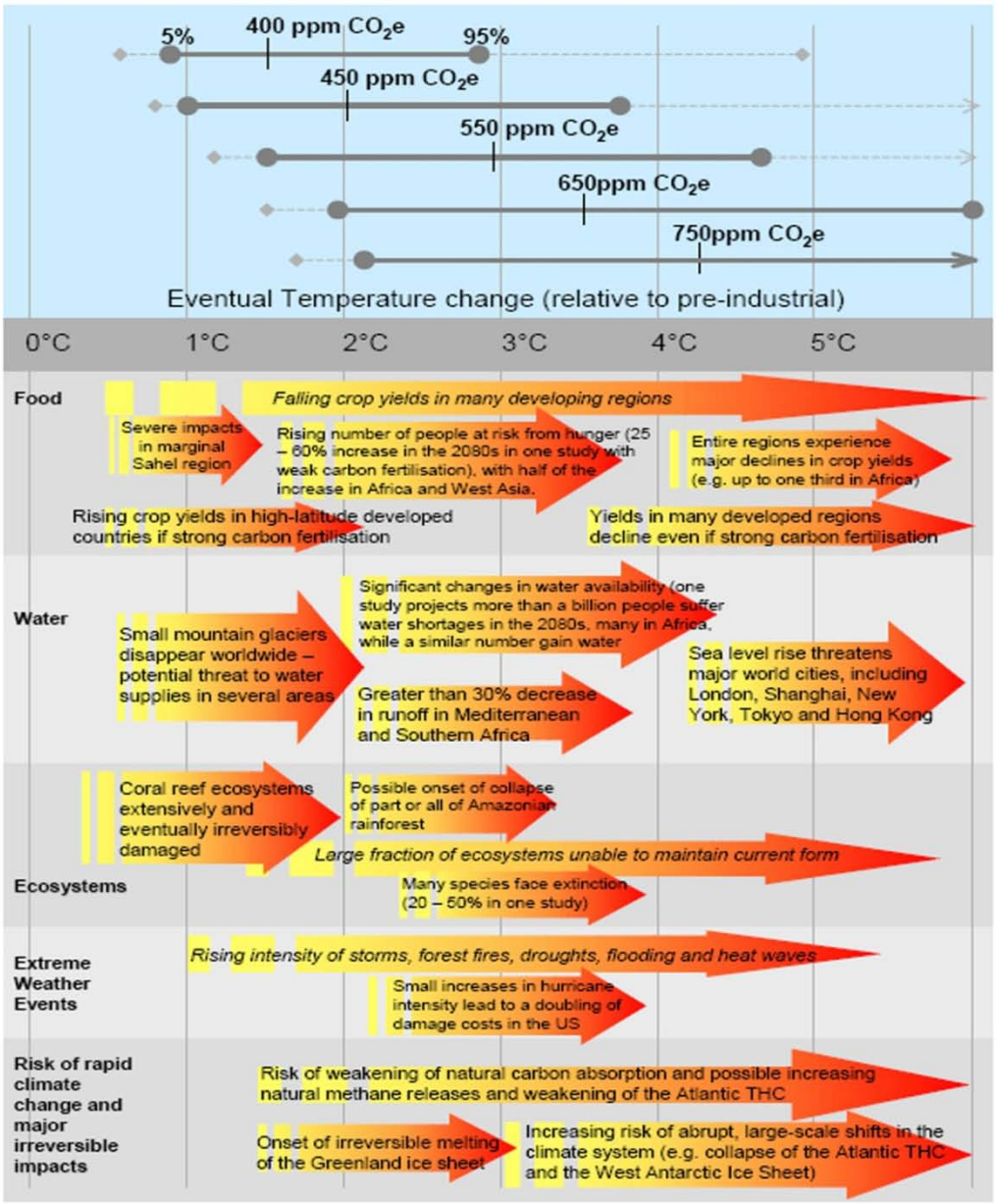

Figure 1.4: Stabilization Levels and Probability Ranges for Temperature Increases

Source: Stern, N. (2007). The economics of climate change: The Stern Review. Figure 2 at page V. Cambridge, UK: Cambridge University Press.

Top panel: (1) Range of temperatures projected at stabilization levels between 400 ppm and 750 ppm CO2 at equilibrium. (2) Solid error bar is the 5%–95% range based on climate sensitivity estimates from the IPCC 2001 and Hadley Centre ensemble study. (3) Dashed error bar is the 5%–95% range from eleven studies.
(4) Vertical line is the mean of the 50th percentile point.
Bottom panel: The range of impacts expected at different levels of warming

Section 1.4: Related Work and Research Questions

Planners and policy makers have increasingly recognized the ecological and socio-economic implications of carbon management. Researchers have engaged in critical analysis of urban carbon reduction strategies (Betsill and Bulkeley, 2008; Bulkeley and Betsill, 2003; Rutland and Aylett, 2008; Slocum, 2004), sustainability (Berke, 2002; Berke and Conroy, 2000; Conroy and Berke, 2004), ecosystem management (Brody 2003; Brody and Highfield, 2005), and emission trading (Bailey, 2007). Furthermore, some scholars have studied the role of local land use policy in climate change (Bizikova et al., 2007; Burton et al., 2007; Swart and Raes, 2007; Brody et al., 2008). However, there is little research that combines a city land use model with climate change policies.

In this paper, an integrated approach is adopted for low carbon city planning and development. This approach not only develops a theoretical model based on geographic analysis of climate management (Bumpus and Liverman, 2008), but also attempts to integrate environmental, social, economic and other dimensions into a composite whole through local land use planning. Additionally, some researchers have identified the external and internal indicators that influence the quality of local comprehensive land-use plans (Berke et al., 1996; Lindell and Brandt, 2000; Lindell and Perry, 2001; Lindell et al., 1996; Norton, 2005; Tang, 2008; Tang and Brody, 2009). This research method will be used to monitor and evaluate local land use

plans and updates while setting forth recommendations on adoption of low-carbon city strategies into land plans.

Building low-carbon cities is a popular, but not a brand new, idea in the planning field, especially in planning policies. Some planners are concerned about reducing personal carbon footprints and investing money to reduce the risks of major changes at a global level (Stern, 2007). Others have restructured state policies to control carbon emissions at the community and regional level (While et al., 2009). However, a systematic low carbon planning framework has still not been developed. Even though there are already some planning policies that indirectly address climate protection, there are still no measures that emphasize or incent capping carbon dioxide emissions. Since the 1980s, planners have focused on integrating smart growth and sustainable development, but have not taken this one step further to make any direct links with the low carbon issue (APA, 2008). Therefore, the main purpose of this paper is to attempt to define a practice model for low-carbon city planning and evaluate it quantitatively in existing and new local comprehensive land use plans, while considering that the carbon issue should be one of the core parts of a city's comprehensive plan. Now, more than ever, it is urgent and desirable to create low carbon, sustainable cities and, at the same time, achieve sustainable socio-economic development.

To date, no empirical model has been developed to quantitatively measure the implementation of low-carbon principles in a real life planning process. In

recognition of this gap in the current local carbon city field, this study proposes to address two research questions:

(1) How well do the fastest growing cities in the U.S. implement low-carbon principles in their local comprehensive land use plans?

(2) How can local land use plans be improved to achieve the goal of low-carbon cities?

Section 1.5: Organization of the Thesis

This thesis contains five main chapters that respond to the two afore-mentioned research questions. The main purpose of this study is to elaborate on the implementation of low-carbon city approaches while focusing on local land use decisions. Through evaluating the local comprehensive plans of the top 50 fastest growing population cities in the U.S., key ideas, concepts, and indicators for improving low carbon planning are identified and examined. Results measure the advantages and disadvantages of local plans to achieve low carbon city planning and provide direction on how cities can improve their approaches to address the carbon issue.

Chapter Two, Origins of Low-carbon Cities, explores the fundamental principles of low-carbon cities based on planning history and policy management. Although there is currently no concrete definition of the term “low-carbon city,” these principles can be used as a benchmark for creating the low-carbon city form

and evaluating the qualities of the plan. This chapter explores the derivation of the low carbon city concept, which lay the groundwork for the low-carbon city planning model introduced in Chapter Three. Understanding particular historical themes –which continue to be echoed today –is important in order to understand how cities and towns can become more sustainable in the future. Finally, a multi-level governance model for low-carbon cities will be introduced in Chapter Two. Implementing sustainable development while reducing carbon emissions is not only a local effort, but also a global problem which requires coordinated global action and responses at multiple scales of government.

Chapter Three, Approaching A Practical Model, intends to develop and define a model for low-carbon city planning and to identify the dimensions that drive and influence decisions. This theoretical framework curtains three main elements: 1) a low-carbon city structural model, 2) local jurisdiction governance, and 3) monitoring and evaluation. The first element is to collect spatial data and to establish a city structural model. The second element is to prepare a long-range policy plan. The third element is to monitor and evaluate outcomes. In order to measure local comprehensive plans quantitatively, this thesis will use a Five Component Protocol for monitoring and evaluating the progress toward achievement of low-carbon city goals. The five components are 1) factual basis; 2) goals and objectives; 3) policies, tools and strategies; 4) inter-organizational coordination; and 5) implementation and monitoring.

Chapter Four, Research Methods, describes the sample selection, indicators definitions, and the data analysis procedure. In Chapter Four, the paper addresses more concrete issues. The sample strategy is to select the comprehensive plans of the top 50 fastest growing population cities in the U.S. The preceding conceptualization of plan quality leads to the five component protocol. In each component, there are several indicators which will be used to evaluate each plan to assess whether it has addressed the 35 indicators. Each indicator is scored on a scale of 0-2.

Chapter Five, Results, presents the five plan components, as well as each indicator within a component. Results will reveal opportunities to improve local plans and develop low-carbon city plans. Those two chapters will answer the research questions statistically.

Chapter Six, Discussion and Conclusion, will summarize the findings and give a series of planning recommendations in order to achieve low-carbon city development at the local level. Finally, this chapter will summarize the answers to the two research questions, identify research limitations, and recommend future work.

Chapter Two:

Origins of Low-carbon City

This chapter first explores some fundamental principles of a low-carbon city. Although there is not a well acceptable definition of the term "low-carbon city," it is part of sustainable development. These principles can be used as a benchmark for creating a city form or evaluating the qualities of a comprehensive plan. The chapter then provides an overview of major planning theories and practices influences on the concept of low-carbon cities and sustainable development in the past two centuries. Understanding particular historical ideas, especially those that continue to be echoed today, is important in order to understand how cities and communities can become more sustainable and low-carbon in the future. Finally, a multiple level policy governance context for low-carbon cities will be introduced that spans a global policy framework to local efforts. Without an effective global policy approach, local approaches are impossible, and vice versa.

Section 2.1: Fundamental Principles of a Low-carbon City

A few development plans have already adopted low-carbon development principles but use other names, such as energy efficient city (Ho and Fong, 2007), Transit Oriented Development (TOD), and sustainable building and lifestyles (Reed and Wilkinson, 2009). Some of these ideas focus on using renewable energy while

integrating it into cities' comprehensive plans. For instance, Manchester, UK, managed energy consumption and conservation in the commercial, accommodation and transportation sectors. Manchester established clear energy-saving and new energy utilization targets to reduce carbon emissions. Some low-carbon emission ideas adopt spatial strategies in planning, such as compact cities and eco-cities. Melbourne, Australia, is an excellent example, where various levels of government have implemented TOD principles. The city formed a new industry pattern based on TOD and also made policy changes relating to GHG emissions and water resource management. Other ideas for reducing CO_2 emissions mainly focus on policies, regulations and actions. For instance, another UK city, London, which adopted a green initiative as part of a climate change action plan, aims to reduce its GHG emissions by 60 percent from 1990 levels by the year 2050 (London City Hall Report, 2007). Based on this initiative, London also set up key priorities such as improving the energy efficiency of individual buildings, minimizing emissions from travel, and developing green procurement standards.

Although many countries and regions are already taking action to address the carbon issue, the term "low-carbon city" is so new that a consensus has not yet been reached on how to define it. Nevertheless, it leads towards a goal of sustainability. The concept of "sustainable development" was espoused as a mainstream planning theory in the latter part of the 20th century. It was defined as "*development that meets the needs of the present without jeopardizing the ability of future generations to meet their own needs*" in the report of the World Commission on Environment and

Development (WCED), Our Common Future (1987). According to the definition, a sustainable development project should balance between ecological protection, social equity and continued economic growth. However, up to now, the goal of sustainable development has been widely espoused globally, but needs to be transformed into local practice through planning processes and policies. The primary discussion of climate control has become a major focus for planning researchers and policy makers and often related to the debate on achieving sustainable development since the 1990s (IPCC, 2007c; APA, 2008; While et al., 2009). In these debates the reduction of carbon dioxide emissions, especially anthropogenic greenhouse gas emissions, is the most important subject. Hence, the dominant direction of sustainable development practice has moved to carbon control, which has profound implications for the practice of community and regional planning (While et al., 2009). Therefore, it is safe to say that the low-carbon city is within the framework of sustainability, and is an extension of current sustainable development theory and practice. Cities must be involved in defining a low-carbon city from a local perspective. The challenge is how to encourage local social equalities within a framework of global sustainability (Roseland, 1997).

In conclusion, the fundamental principles of a low-carbon city are defined as follows:

(1) Low-carbon city planning must be done within the context of sustainable development planning and implementation. Low-carbon cities are part of the

global ecological system, requiring coordinated action at multiple scales (global to local), but oriented around local management within a global framework.

(2) Low-carbon city planning must focus on carbon minimization in all spatial scales, but oriented around local land use planning.

(3) A comprehensive local land use planning approach is needed to reduce the amount of carbon emissions through mitigating climate change and preparing communities for adaptation.

Clearer strategies for low-carbon cities will be introduced in the next chapter based on these principles to reduce risks of "dangerous impacts on ecosystems and human health" (APA, 2008, p6) due to high carbon emissions to the atmosphere.

Section 2.2: Evolution of Low-carbon City Theory and Practice

Initially, five dimensions of low-carbon cities as planning ideals will be discussed in this section. There are many dimensions that identify sustainable development which include low-carbon city dimensions, while there are differences in analysis, emphasis, and strategy. This thesis uses Berke's (2008) five dimensions of green communities but redefines them to cover all themes linked to low-carbon cities. They are 1) harmony with natural systems; 2) human health; 3) spiritual well being and renewal; 4) livable built environments; and 5) fair-share community. These dimensions also will be used to review the historical urban planning theories that have influenced the concept of low-carbon cities in the past two centuries.

Section 2.2.1: Five Dimensions of Low-carbon Cities

Harmony with nature

Our ecosystem is an interconnected web that links human beings, other creatures and the natural environment together. In other words, human communities are part of an ecosystem which should comply with environmental principles and maintain system harmony and balance. In order to attain harmony with natural systems, a low-carbon city should be one where essential consumption is not more than nature can produce or re-use while discharge of wastes are at a minimum. Furthermore, a low-carbon city adjusts the system in response to expected climatic effects. The natural environment is a capital asset; mitigation and adaptation strategies help protect clean air and water, sequester carbon, and mitigate droughts and floods.

Human health

This dimension is linked to the natural system directly and emphasizes the living conditions of people. Usually “health” refers to being free from disease, hazards or safety. Historically, an overcrowded industrial city in the 19th century with a frequent shortage of decent housing, clean water, and basic sanitation is the primary reason for promoting the concept of sustainable development and low-carbon cities (Frank, Engelke, and Schmid, 2003; Frumkin, Frank, and Jackson, 2004). Instead of that, we now have relatively low-density, auto-dependent suburbs with a much higher quality of housing and infrastructure, but with many other problems. For example,

uncontrolled suburban sprawling development patterns come with higher rates of storm water runoff and increased potential for tornado, hurricane and flood disasters (Bernhardt et al., 2008).

Spiritual well being and renewal

In this dimension, human communities have inherent connections to natural systems and should seek out nature for spiritual well being and renewal (Beatley, 2004). Technology-dominated life in this era creates a "nature-deficit disorder" caused by a declining amount of forests, fields and streams for recreational use (Louv, 2007). Therefore, low-carbon cities need to be established to connect humans with the natural environment. Strategies like preserving native species from climate change, creating urban gardens to reduce urban heat islands, and protecting wetlands' stable surface temperature all enhance physical and spiritual health and provide residents with a sense of commitment to place (Berke, 2008).

Livable built environments

This dimension emphasizes physical land use design features, such as urban forms, density, and mixed use, in low-carbon city planning. Livable built environments encompass urban design tools that are adapted to desired activities, quality lifestyles, and aspirations of inhabitants (Hester, 2006; Lynch, 1984). A low-carbon city should encourage higher density development patterns, different transportation choices, green building techniques and so on, to support a sense of

space with attractively built environment vistas, like visually walkable streets and pleasing landscapes.

Fair-share community

In this dimension, a fair-share community is one in which the damage of one place's action imposed on other places in the world should be minimum while producing less waste and using fewer resources. For example, all counties and regions are affected by climate change, which is mostly caused by developed countries. However, the poorest countries suffer the most from shortages of food and drinking water, as well as increased extreme weather conditions. A low-carbon city involves more than ecosystem conservation and built environment design; it embraces the need for equity.

Section 2.2.2: Overview of Planning History

Understanding the knowledge of the historical context is an excellent starting point to improve the understanding of how best to attain low-carbon goals in the planning process. This section will look back over the past two centuries on the planning theory and practice "associated with the relationship between human settlements and the environment" (Berke, 2008) in order to provide a historical connection for research relating to the concept of low-carbon cities.

Although the term “low-carbon city” is new, the concept is from the late 19th century and early 20th century. From 1898 to the 1940s, three utopian urban forms have shaped the debate about low-carbon city concepts. They are Ebenezer Howard’s *Garden City*, Le Corbusier’s *Radiant City* and Frank Lloyd Wright’s *Broadacre City*. At that time, urban planners and managers were drawing attention to the deterioration of urban conditions caused by the Industrial Revolution, particularly public health, and realized the need for improved living environments. One of the most influential of these pioneers was Ebenezer Howard.

Howard’s seeking of “beauty of nature, fields and parks of easy access, pure air and water, bright homes and gardens, no smoke, no slums, social opportunity, plenty to do, and greater cooperation” is still central to the task of creating low-carbon cities, but the emphasis has shifted (Howard, 1902, Page 46). He created a polycentrist low-carbon urban form to solve the awful human health conditions of extremely dense 19th-century industrial cities. Subsequent to Howard’s idea of *Garden City*, Wright’s *Broadacre City* and Le Corbusier’s *Radiant City* presented two opposing directions of urban planning in the 1930s. Wright advocated the use of new technologies - automobile and electricity – that “would make it possible for everyone to live his chosen lifestyle on his own land” (Fishman, 1977, Page 9). *Broadacre City* would be designed not only in harmony with natural systems, but also intimate with the patterns of individual life. His vision was most closely related to dimensions of a low-carbon city except for decentrist planning which initiates urban sprawl. Le Corbusier designed high density towers set within large green open spaces to avoid crowded,

polluted, and disease-ridden living conditions. Hall (1992) stated that Le Corbusier's city was to be "A well mapped-out scheme, constructed on a mass production basis, can give a feeling of calm, order and neatness, and inevitably imposes discipline on the inhabitants" (Page 205). Le Corbusier's *Radiant City* is a centrist view that enhanced human health and the livable built environment dimensions of a low-carbon city.

Later, after World War II, discussion of sustainable development and low-carbon cities focused on the revolutionary environmental movement. Lewis Mumford and Ian L. McHarg were seeking the implementation of this idea. Although Mumford is a writer rather than a planner, just like Howard, he played a central role as America popularized the garden city idea. His solution for the problems of the overcrowded industrial city advocates the decentralization of population to achieve a better balance of city and countryside. McHarg's book, *Design with Nature* (1969), is a milestone in modern urban planning theory with ideas that have influenced current urban planning theory and practice. His idea of designing with nature played a crucial role in bringing environmental and urban planning concerns together in the mid-20th century. Later books have emphasized the importance of ecological principles in urban development. *Silent Spring* (Carson, 1962) called attention to the dangers of pesticides and other toxic chemicals. Additionally, Barry Commoner's book, *The Closing Circle* (1971), warned of the impacts of pollution and resource consumption in a technological society. All of these books from the 1960s and 1970s helped catalyze the modern environmental movement.

Jane Jacobs is also a significant 20th century writer in the urban planning field whose specific emphasis is on pedestrian-oriented urban forms. In The *Death and Life of Great American Cities* (1962), Jacobs criticized the modernist planning models that have destroyed many existing inner-city communities. One of her major goals is to preserve the uniqueness inherent in communities upholding redundancy and vibrancy of neighborhoods against order and efficiency. She described in detail what makes dense urban neighborhoods work and how modern city-building practices undermine many neighborhood qualities. Her ideas have served as an inspiration to many later urban activists including the "New Urbanists." In the 1970s, the most influential book at that time – and also the first book which used the term "sustainable development" –was *The Limits to Growth* (Meadows and Forrester, 1974). The *Limits to Growth* team analyzed the basic factors most likely to limit growth: population, agricultural production, natural resources, industrial production, and pollution. This work first used computer models to analyze the human future to answer critical questions such as whether a growing human population and resource consumption were sustainable.

The contemporary debate on sustainable development and low-carbon cities began in the 1980s. Three mainstream urban planning theories emerged in this period: *Ecocity*, *New Urbanism* and *Smart Growth*. In the 1980s, Richard Register is a key researcher who promoted the research and practice of *Ecocity* with the goal of a self-contained ecosystem. The Urban Ecology Group established by Register and his friends proposed the concept of urban ecology as a subfield of ecology to analyze the interaction of ecology with the human environment in urban or urbanized settings.

They paid special attention to the effects of urban development patterns on ecological conditions and suggested that urban planners use urban design strategies and new building materials to promote a healthy, biodiverse, urban ecosystem. *Ecocity* is a more extreme urban form of *Radiant City.* Register (2006) claims that "the city is designed to conserve energy and materials while turning wastes into resources . . . and restoring natural habitats, the ecological footprint shrinks to an optimal" (Page 36).

Since the early 1990s, the concepts of *Smart Growth* and *New Urbanism* have arisen. Both concepts promote various aspects of sustainable development and are related to low-carbon cities, although they are not the same. The *Smart Growth* program focuses on compact city design, mixed-use development and TOD by integrating transportation and land use. Compared to *Smart Growth*, *New Urbanism* is rooted in physical design and has revitalized the idea that the main purpose of urban planning is visionary design more than policy. They encourage high density development patterns and mixed-use design with pedestrian friendly streets. They also plan compact towns to "transform the relentless auto-dominated scale of suburbs . . . and return [regions] to the most basic urban design ideas—diversity, human scale, and preservation" (Calthorpe and Fulton, 2001, Page 7). However, both concepts have been criticized for failure to offer a more general vision of an urban form. *Smart Growth* emphasizes community-wide land use and infrastructure policy but does not offer physical design perspectives and layouts even though it includes urban design principles. In contrast, *New Urbanism* provides more detailed and site design but only has minimal guidance for subsequent effects on environmental preservation, refilling

inner cities and affordable housing supply. Because of these limitations, a more general vision of urban planning is necessary. Low-carbon city planning would extend the two concepts to embrace the ecosystem, human health, spiritual well being and renewal, livable built environments, and fair-share community. Under this vision, *Smart Growth* and *New Urbanism* concepts can play a vital role as mid-range visions to guide regions, cities and communities towards a long-range low-carbon city.

The above visions are theoretical urban form guidelines for the practice of low-carbon city planning. In sum, Table 2.1 summarizes how the five dimensions of low-carbon city are related to the early ideas of low-carbon urban planning. It is easy

Table 2.1: Low-carbon City Dimensions Promulgated by Visions of Planning Theories

Urban Form	Harmony with Natural Systems	Human Health	Spiritual well-being and Renewal	Livable Built Environment	Fair-share Community
Garden City	1. Green Belts 2. Surrounded by agriculture lands	1. Pure air and water		1. Beauty of nature 2. Access to parks and gardens	
Broadacre City	1.Ecosystem is an organic and built environment is part of it		1.Lifestyle attached to land 2.Jeffersonian agrarian ideal	1.Plan and control infrastructures	
Radiant City		1.Cure pollution and disease	1.Efficient 2.Neatness and self-control		

Modern Environm-ental Movement	1.Design with nature 2.Land classification and suitability	1.Safety from disasters			
Ecocity	1.Self contained structure 2.Reduce automobile to save ecosystem	1.Biodiversity for healthy living	1.Natural lands for children	1.Accessibility by proximity	1.Virtues of density 2.Shrink footprints
Smart Growth				1.Compact city design 2.TOD	
New Urbanism				1.Walkable streets 2.Social connection	

to see that *Ecocity* contains all of the low-carbon city dimensions. The second one is the vision of *Garden City* which contains four dimensions. Remarkably, the visions of *New Urbanism* and *Smart Growth* are similar and focus on the livable built environment dimension, but are not inclusive of all dimensions. Besides the concepts of those urban forms, the global level cooperation and policy guides have become regular forums in low-carbon city governance in recent years, which will be discussed in the next section.

Section 2.3: The Multi-level Governance of Low-carbon City

Box 2.1 Defining Governance

There are diverse definitions of the term of "governance;" generally speaking we can say it is a "system of governing," a means for "authoritatively allocating resources and exercising control and co-ordination" (Rhodes 1996:653), in which the multilateral treaties, for example UNFCCC, are the most important actors instead of the national, state, or local government.

Most countries and local jurisdictions are taking actions to reduce carbon emissions already, such as Germany, the United Kingdom and the state of California in the U.S. Those countries and regions facing different circumstances do use different policies to attack climate change. But approaches by individual countries or regions or cities are not enough. Each country is only a part of the whole problem. Therefore, an international response is necessary, based on "a shared vision of long-term goals and agreement on frameworks for action" (Stern, 2007), to help each country to play a role in meeting common goals. In this section, the challenge of achieving carbon governance will be illuminated, a challenge that occurs at multiple levels, from the global to the local. First, the global carbon policy framework will be explored. Indeed, an international policy framework is already built, and the UNFCCC and the Kyoto Protocol have provided international co-operation associated with many partnerships around the world. Second, the policy processes of climate change will be introduced at the national level. Each country has different approaches,

but most of them focus on energy and transportation policy. The U.K. and Australia are two examples of countries that are leaders in adopting low-carbon policies. Finally, the Cities for Climate Protection (CCP) program will be introduced. This program plays an important role in multiple level governance of the carbon issue to meet global commitments to reducing GHG emissions, since human activities that cause climate change are very localized (Wilbanks and Kates, 1999).

Table 2.2: Major Milestones in Global Carbon Governance

Date	Events
1987	Release the Brundtland Report, Our Common Future
1988	Established the "Toronto target" to reduce GHG emission to 20% by 2005
1988	the Intergovernmental Panel on Climate Change established
1992	Earth Summit in Rio de Janeiro established UNFCCC
1997	Kyoto Protocol adapted to the UN Climate Convention
1997	The IPCC Third Assessment Report finds correlations between human activities and climate change.
2005	First meeting of the Parties of the Kyoto Protocol holds in Montreal, Canada
2008	180 nations ratified the Kyoto Protocol, which sets binding targets to reduce an average of 5% GHG emissions below 1990 levels between 2008 to 2012, when the first Kyoto Protocol ends

Section 2.3.1: Global Carbon Governance Framework

The worldwide policy framework for the carbon issue, or climate change issues, has been primarily shaped by the United Nations. Table 2.2 shows major milestones in global carbon governance. In 1983, the U.N. Commission on Environment and Development held the first conference and established and released a famous report in 1987 titled *Our Common Future*. The report succeeded at calling global attention to global environmental issues and developing a common formulation of this concept. One year later, the 1988 World Conference on the Changing Atmosphere was held, which was the first effort to facilitate international political co-operation on climate change. The topic was Implications for Global Security, often known as the Toronto Conference. In the conference, the "Toronto target" to reduce GHG emission by 20 percent by 2005 was established. Shortly thereafter, the Intergovernmental Panel on Climate Change (IPCC) was established by the U.N. agencies to assess scientific evidence of human impact on climate change and ways to mitigate the impacts. From then on, the IPCC's reports (the fourth report was published in 2007) have become an official reference for tracking climate change and its impacts.

The second conference of the UN Commission on Environment and Development (UNCED), held in Rio de Janeiro in 1992, produced the establishment of the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC became the main body to push the adaptation of Kyoto Protocol in 1997. Both the UNFCCC and Kyoto Protocol are the core multilateral treaties of global

carbon governance framework for climate change that also give national policy guidance. Furthermore, the two treaties created a global carbon market and established new institutional mechanisms to provide the foundation for future climate policies (Bulkeley and Betsill, 2003). By 2008, 180 countries had ratified the Kyoto Protocol, which aims to reduce an average of 5 percent GHG emissions to 1990 levels over the entire period from 2008 to 2012, when the first Kyoto Protocol period ends. The exact target for each member country varies based on their historic emission levels and capacity for climate change. The specific policies for the U.K. and Australia will be detailed in the next section.

Section 2.3.2: Carbon Governance at the National Level

As discussed in the above section, global governance has provided a policy framework. However, negotiations and processes occur between and within countries' political boundaries. Moreover, the implementation of the international framework is dependent on the political framework at the national level. In this section, national carbon governance will be illustrated by the U.K. and Australia. In each case, national efforts to address GHG emissions are linked to energy and circulation policies, and have been shaped by discussion about the relationship between the economy and environment (Bulkeley and Betsill, 2003).

The U.K. government set a target for achieving a 20 per cent reduction from its 1990 level by 2010 and developed policy strategies to achieve this goal. The U.K.

Change Act adopted legally binding carbon emission targets based on 1990 levels through actions in the U.K. and the whole world in 2008, which aimed to reduce GHG emissions by at least 26 percent by 2020 and at least 80 percent by 2050. In order to meet these targets, the emphasis of the U.K. government was on utilizing the carbon tax and improving the efficiency of energy use, especially at the national level. A carbon tax is an effective policy tool to reduce greenhouse gas emissions; however, an increasing critical argument about the carbon tax is that this does not lead to significant change in consumer behavior. The other highlighted point is improving the efficiency of energy use through the creation of the Home Energy Efficiency Scheme for low-income families, establishing the Energy Saving Trust and conducting public energy information campaigns.

The other leader in national level governance regarding climate change is Australia. In 1997, the former Prime Minister, John Howard, stated that “we have an obligation to define and protect Australian interests, Australian jobs and Australian industry. We also owe it to future generations of Australians to play an effective role in the global reduction of GHG emissions.” The Toronto Conference in 1988 was the first movement for setting national carbon policy in Australia. In 1992, the Australia government ratified the UNFCCC and adopted the National Greenhouse Response Strategies (NGRS) to pursue a reduction target to achieve a 20 percent reduction of GHG emissions by 2000. The NGRS focuses on energy efficiency and economy.

Section 2.3.3: Carbon Governance at the Local Level

International and national policies can set targets addressing climate change but need to achieve it by local actions. Local actions to reduce GHG emissions started in 1991 with the Urban CO_2 Reduction Project Program, which promoted the development of local strategies to reduce GHG emissions and "quantification methods to support such strategies" (ICLEI, 1997). Two years later, based on this program, the International Council for Local Environmental Initiatives (ICLEI) initiated the Cities for Climate Protection program (CCP), which attempts to build and support a global network for local governments to address climate change issues and to represent local governance within national and international governance networks (Bulkeley and Betsill, 2003).

The most essential objective of the CCP program is recruiting local governments whose collective carbon emissions represent 10 percent of the global total, which provides an opportunity for local authorities to link the global climate change problem to their own GHG emissions. The member cities also can develop national and regional campaigns with a number of countries' governments. For example, the India, Mexico and South Africa CCP campaign is funded by the European Commission (EC). The idea is to stimulate members to be part of a global network and share the techniques and experiences to achieve common targets.

The other goal of the CCP program is to enhance local capacity for mitigation. Participants in the program must pass a resolution or a formal declaration reflecting

their intention to reduce impacts of climate change. Members then need to pass five milestones of their local policy. The CCP milestones are to 1) Conduct an energy and emissions inventory and forecast; 2) Establish an emission target; 3) Develop a local action plan to achieve that target; 4) Implement policies and measures; and 5) Monitor and verify results (ICLEI 2008). These milestones are a part of the low-carbon city policy management system discussed in the next chapter.

Although climate change effects are global problems requiring international action, how to mitigate these impacts are endorsed and governed at multiple levels, which call for local actions. The role of local jurisdictions is particularly critical in setting the policies to coordinate all levels of policies.

Chapter Three:

Approaching A Practical Model

The main intention of this chapter is to illustrate the conceptual low-carbon city land use model, three key elements in the land use planning program, and the Five Component Protocol used to monitor and evaluate land use plans. First, a practical model will be discussed which consists of three parts: 1) input – land use values; 2) a land use planning program that helps regions, cities and communities complete visions and plans to achieve 3) output – low-carbon city land use patterns. Next, three key elements and their relationships in the land use planning program will be explained, including the city structural model; local planning governance; and monitoring, evaluation and updating. Among them, the emphasis is on the last one because it can feed into the others and the outcomes can be illustrated and measured quantitatively. Finally, the chapter introduces the Five Component Protocol in the monitoring, evaluation and updating element and will use it to evaluate local plans quantitatively in the next chapter.

Section 3.1: The Low-carbon City Conceptual Model

This thesis intends to develop and define a practice model of low-carbon city land use planning and to identify the planning program that reflects the way that low-carbon city planning decisions are made and helps stakeholders and decision

makers to integrate the tools into the stages where they are best suited. This conceptual model (Figure 3.1) frames the organization of relationships between land use value, the low-carbon city planning program and outcomes (Berke and Godschalk, 2006).

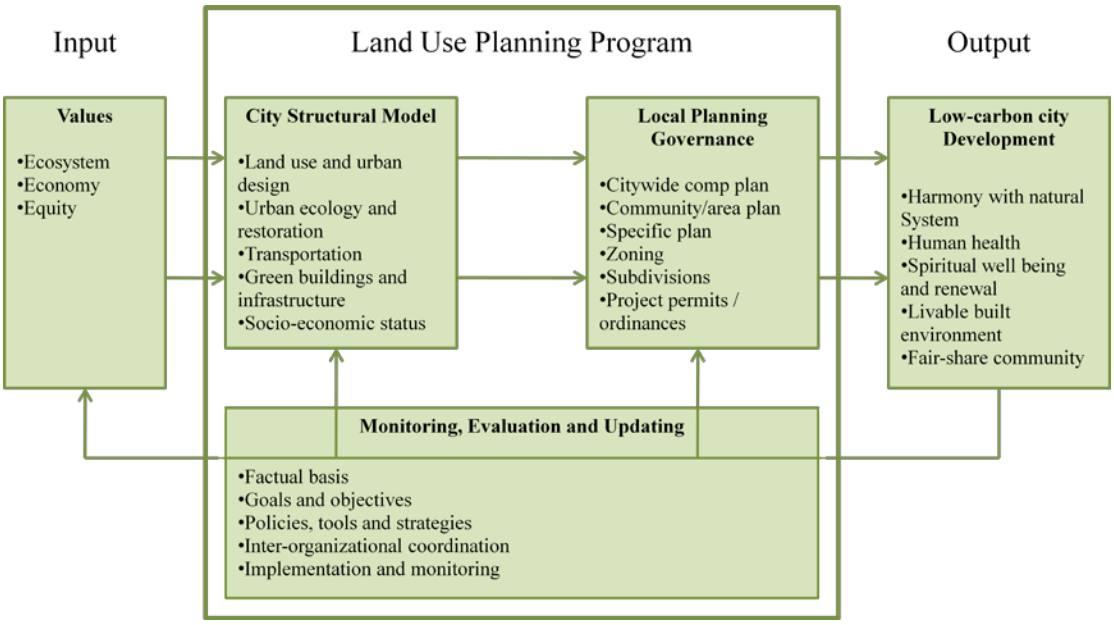

Figure 3.1: Conceptual Model of Low-Carbon City Land Use Planning

Starting with input, the planner should understand the goals and values of land use when the plan is prepared. There are three land use values from different stakeholders' viewpoints of future urban development and changes: ecosystem values, economy values and equity values. Ecosystem protection values define not only physical systems, but also human habitat and human needs. These values require scientific knowledge of natural systems accumulated in order to translate

into findings for land use plan preparation. Ecosystem protection values should call for sophisticated environmental quality monitoring systems and precise performance standards in the local land use planning process. Economic development values mean defining the supply of suitable land for development by managing the land market. The most obvious profit is the sale of land and buildings. In this regard, land is a commodity that affects the economy by identifying it as suitable for development or not, or by limiting the land type, location, and density, and so on. Equity values depict environmental justice and social equity. A city is a place of conflict about safety, opportunities, services and resources. The planner should seek a balance between conflicting requirements and ensure a fair treatment of future generations.

The following step, translating the input values to low-carbon city outcomes, is to go through a low-carbon land use planning program. The central box in Figure 3.1 is the land use planning program, which combines three elements together: 1) a city structural model; 2) local planning governance; and 3) monitoring, evaluation and update. The relationship between them will be detailed and explained in Section 3.2. This program helps cities identify impacts, costs and other options by using spatial analysis and transfer the decision to local governance through land use strategies and policies. Then the effectiveness of the policy – land use plan – should be monitored and evaluated, and updated if necessary. Data collection in all sectors of a city will identify past and current land use conditions and impacts of various land use decisions. Furthermore, analysis and interpretation of the information is essential to

start spatial analysis and policy governance. Analysis of the assembled data explains relationships between policy decisions and data, and informs design and policy formulation. Finally, outcomes should reflect low-carbon city development that strikes an appropriate balance among five dimensions: harmony with natural systems; human health; spiritual well being and renewal; livable built environments; and fair-share community (Berke, 2008). A detailed description of the five dimensions is in Section 2.2.1.

The low-carbon city conceptual model describes an overview of a low-carbon city planning procedure. Among them, a land use planning program is the most essential component, and it will be described in Section 3.2.

Section 3.2: Three Key Elements in the Land-use Planning Program

This section is the central dimension in the model which serves three key elements: 1) city structural model, 2) local planning governance, and 3) monitoring and evaluation. The first element provides data collection and analysis for the land use, ecosystem, transportation, infrastructure and socio-economic components of a low-carbon city structural model. The second element is an overview of a local land use planning framework that includes a citywide comprehensive plan, community/area plans, specific plans, zoning, subdivisions, and project permits/ordinances. The last element in the land use planning program is monitoring and evaluation which offers general plan evaluation criteria – Five Component

Protocol – to guide the creation of high quality land use plans. Because the focus of this thesis is on plan making and plans measurement, the method for creating monitoring and evaluation criteria is emphasized.

Section 3.2.1: A Low-carbon City Structural Model

A low-carbon city structural model, as the first element in the land use planning program, establishes a spatial analysis system to collect, collate and analyze referenced spatial data. The model should state current conditions and trends about the planning site which encompass five main aspects: land use and urban design; urban ecology and restoration; transportation; green buildings and infrastructure; and socio-economic status. The outcome of the low-carbon city structural model is a summary of problems and visions to be addressed during the planning process.

A number of cities around the world have developed their city models to solve the existing urban problems in order to achieve a low carbon society. Although the destination may be far, and the best way even not yet known, a number of models and tools are proving useful. There are two models, linear metabolism city model and compact city model, which have significantly influenced the low-carbon city model. It is now accepted that the compact city model is the core of sustainable urban research. However, there is some debate about this model, mostly because of the lack of precision in the description of urban models and lack of focus of arguments. Therefore, many urban planners developed their own models from the

compact city model and some of them are used in practice, such as the Eco-village model, eco-neighborhood model, and so on. After comparing and contrasting them, the low-carbon city model is redefined as the solution for the sustainable urban form.

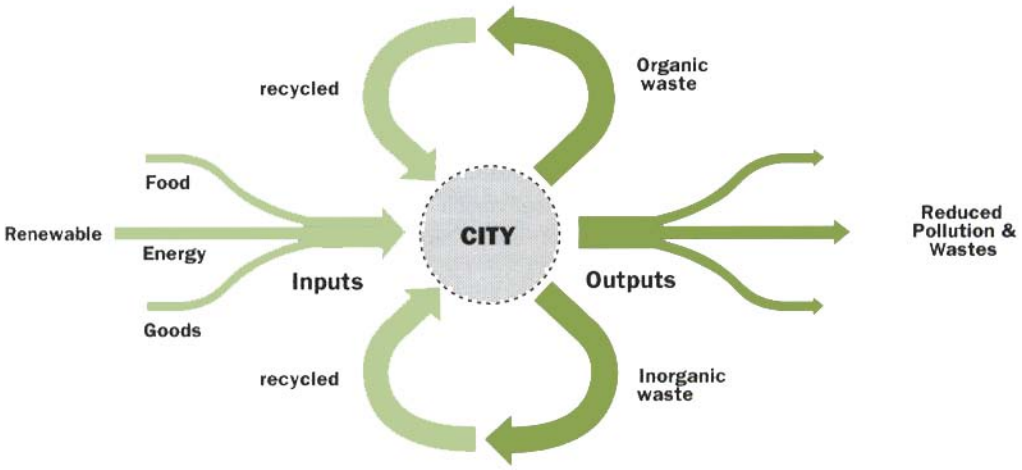

Figure 3.2: Linear metabolism city model

Source: Girardet, H. (2008). *Cities People Planet: Urban Development and Climate Change.* Chichester, West Sussex, UK: John Wiley & Sons. P125

Linear metabolism city model

The term "metabolism" can be defined as the sum of all the biological, chemical and physical processes that occur within an organism or ecosystem to enable it to exist indefinitely (Girardet, 2004). Girardet claimed that "We must recycle materials, reduce waste, conserve exhaustible energies and tap into renewable ones." (Girardet, 1992, Page 124) Figure3.2 demonstrates a linear model

on how to recycle, reuse and reduce urban production, consumption and disposal in the overall ecological viability of urban systems. Outputs also need to become inputs and feed back into the urban production system, with routine recycling (paper, materials, plastic and glass), and the conversion of organic waste, returning planet nutrients back to farmland that feeds cities to keep the soil in good health (Rogers, 2000).

The 'Compact City' model

In the 21st century, the compact city has been widely accepted, particularly in land use planning policy, as the most effective solution to achieving sustainable urban form (Urban Task Force, 1999). However, the concept of the compact city is still not clear, especially what the structure and form of such a city might actually be. One initial principle is that the compact city resembles the medieval city with a concentration of activities in a highly dense city with clear boundaries to the countryside. The vision of a compact city is certainly influenced by historic European towns and cities that have densely developed cores which are seen as ideal places to live and work. But many modern industrial city conditions like public transportation, public facilities and so on do not have a clear presence in the compact city model.

Low-carbon city model

When comparing the two models above, the linear metabolism city model and compact city model, it is clear to see that both of them can work well under particular conditions. However, the linear metabolism city model is an ideal model which emphasizes the use and reuse of resources. It is more general than the compact model. The other one is a detailed structural model but has no clear definition to support it. Therefore, following the concept of those two models, the low-carbon city model is developed. It is explained from five aspects: land use and urban design; urban ecology and restoration; transportation; green buildings and infrastructure; and socio-economic status.

Land use and urban design: In the low-carbon city model, high density and mixed land use not only conserve resources but provide for compactness that encourages social interaction. Good urban structure should encourage more people to live near city services like education, leisure and shopping, etc., which they require on a regular basis. Buildings themselves require sensitive design, using materials that are less environmentally damaging and more energy efficient, and structures conducive to continuity and adaptability.

Urban ecology and restoration: The urban environment is the human habitat, and therefore the human need, which provides the focus here. The ecosystem approach is potentially compatible with the Brundtland definition of sustainable development, but the alternative construction promoted by environmental and wildlife interests provide a more explicit connection.

Transportation: Transport is a key issue in the model. Transportation systems in a low-carbon city should have the following primary features: (1) the potential of the "street" should be reclaimed to meet different community needs rather than simply to providing a conduit for motor vehicles; (2) walking, cycling and public transport should increase, and not just rely on the private sector to provide those extra resources; and (3) the amount of land which is given over to the motor car should be reduced, particularly surface level automobile parking.

Green buildings and infrastructure: A green building is designed, built and operated in a way that minimizes environmental damage. While ensuring healthy, cozy and safe living, it saves resources such as energy, water, land and raw materials. A variety of sustainable design practices and building materials have come into mainstream construction, encouraged by the emergence of green building standards such as the Leadership in Energy and Environmental Design (LEED) standards.

Socio-economic status: A low-carbon city embraces the need for social equity and economic growth. It should balance conflicting demands between social, environmental, and economic objectives and focus on the long term perspective.

Section 3.2.2: Local Planning Governance

The second element is local planning governance, which should relate to the city structural model in form and extent. It provides local planning policy to avoid penalties and gauge local eligibility in order to build an appropriate city model. This

element is based on U.S. planning institutions. The core purpose of local planning governance is to prepare and adopt a long term plan called a comprehensive plan, master plan or general plan that guides the structural model within a city over a long time frame. A community/area plan, specific plans, zoning, subdivisions, and project permits/ordinances can only be approved when they are consistent with the comprehensive plan, and these plans and ordinances will specify and achieve the goals, objectives and policies of the comprehensive plan.

Local comprehensive plan can be described as a city's vision for future development. It provides facts, goals and policies for translating this vision into a land use pattern and is also the foundation for local land use decisions. A local elected legislative body, city council or board of supervisors, upon recommendation of their planning board/commission, implements its comprehensive plan through its zoning decisions, subdivisions, and other ordinances.

Community/area plan is a part of the local comprehensive plan which supports the policies and visions of the city comprehensive plan. It is often used by a city to plan a smaller area or neighborhood with more details, and sometimes it addresses specific problems in an area, such as commercial and employment areas, mixed-use areas, major city centers and open space areas.

Specific plans can implement a comprehensive plan but are not technically a part of it. These plans provide the most details in specifying land use, identifying open space and the availability of facilities in an area. For example, a watershed plan, climate change action plan, and transportation plan are specific plans. These plans

must be consistent with the comprehensive plan and zoning, subdivision, and public works decisions must comply with the specific plan.

Zoning is regulatory. If we say a city's comprehensive plan is a long range policy document, then zoning ordinances in this city are the local law that classify the specific, immediate uses of land. The success of a comprehensive plan rests in part upon the effectiveness of a consistent zoning ordinance in translating the long-term objectives and policies contained in the plan into everyday decisions. In sum, the purpose of zoning is to implement the policies of the local comprehensive plan.

Subdivisions mean the division of a lot, tract, or parcel of land into two or more parts. In general, the design of the subdivision, the size of its lots, and the types of improvements will be required as conditions of approval. For example, improvements of street construction, sewer lines, drainage facilities, etc. may enforce additional approval depending on local requirements and procedures.

Project permits/ordinances are required in most projects, depending on state and local codes and regulations. In general, a project requires one or more permits.

Local planning governance is not a hierarchical, authoritative structure or a simple combination approach that fits every city. Cities may select some types of plans in the planning framework or they can combine plans as elements into a single hybrid plan. In each case, local planning governance should address particular problems and offer balanced solutions.

Section 3.2.3: Monitoring and Evaluation

The monitoring and evaluation element specifies what the city and what planners are required to do to track plan performance after plan adoption in solving problems, implementing goals and meeting needs. It includes three actions: (1) how well the city can implement low-carbon city planning practices by using specific strategies and policies and tools; (2) to what extent land use development complies with the comprehensive plan; and (3) the degree to which low-carbon objectives and goals are being achieved. Based on the results of monitoring and evaluation of the plans, the effectiveness of the comprehensive plan can be continually assessed and the plan can be updated frequently as well.

There are two reasons why this element is important. First, the monitoring and evaluation element can identify the indicators influencing the quality of a low-carbon city plan and can be useful to local jurisdictions to determine specific strategies in their decision making process. Furthermore, it is also useful to federal and state governments to determine which local authorities are most likely to need technical and financial assistance in implementing their low-carbon land use plans. Second, those indicators can guide land use development to select a more appropriate structure model in the planning process.

A series of research studies led to the development of land use planning and related research on planning quality indicators over the past two decades. Plan quality indicators were initially developed as three components: factual basis

indicators, goals indicators, and policy indicators (Baer, 1997; Berke and French, 1994; Berke et al., 1996). Brody (2003) extended this conception of plan quality by adding another two components – inter-organizational coordination indicators and implementation and monitoring indicators – to the Five Component Protocol. Recently, various researches have exercised this protocol to evaluate plan quality and have significant results. Some studies focused on natural hazards plan quality evaluation (Burby, 2005), some focused on ecosystem management (Brody, 2003; Brody and Highfield, 2005), and some are on urban sprawl (Brody et al., 2008). This thesis also will use the Five Component Protocol to measure and evaluate the land use plan quality and give recommendations for local jurisdictions to improve their comprehensive plans' quality to achieve low-carbon goals.

In sum, the last element is to monitor and evaluate the specific strategies and policies and tools involved in implementing low-carbon city planning practices. The monitoring data feeds into the city structure model that continuously tracks the process for implementation of the plan and evaluates success based on the local planning governance dimensions of policy management. Therefore, major factors that determine how effective implementation will be achieved at the local level can be identified in this element. Those factors serve both as an outcome for assessing the land use planning process, and as a causal variable for assessing the plan implementation (Brody, 2003). In order to understand the effectiveness of low-carbon planning outcomes and measure them quantitatively, a growing number of researchers have been developing the Five Component Protocol for monitoring

and evaluating the progress toward achievement of low-carbon plan goals. The five components are (1) factual basis; (2) goals and objectives; (3) inter-organizational coordination; (4) policies, tools and strategies; and (5) implementation and monitoring (Tang, 2008; Tang and Brody, 2009).

Section 3.3: The Five Component Protocol of Plan Quality

This thesis builds on and extends the Five Component Protocol to evaluate local comprehensive plans and measure the ability of a local plan to integrate and manage a low-carbon city plan. It is well accepted that the protocol itself forms the basis of a high quality plan evaluation; however, it has never been used to evaluate low-carbon city planning. This study makes a large contribution by linking the existing planning literature with the principles of low-carbon city planning. The protocol consists of five components: (1) factual basis; (2) goals and objectives; (3) inter-organizational coordination; (4) policies, tools, and strategies; and (5) implementation and monitoring. Within each component, there are several indicators further categorizing the specific conception of plan quality which will be described in the next chapter in more detail.

Factual Basis

The factual basis of a local plan refers to assessing current and future conditions, identifying problems that come with those conditions, and providing an

empirical foundation upon which goals and objectives depend (Brody, 2003). In particular, the factual basis of a low-carbon city includes two aspects: a city's background information and a local jurisdiction's awareness of climate change. The outcomes should be presented in visual form, such as maps and graphs, to illustrate the population change and impacts, current and future land use development, and boundary of influence. It also should contain written narrative that explains socio-economic conditions, GHG emissions, and other factual information. The quality of a factual basis component can be improved by maps, checklists, or videos to increase people's ability to understand a large amount of information. This component also supports other four components that comprise the low-carbon city plan quality.

Goals and Objectives

Goals and objectives should indicate the development of low-carbon city plans and guide the implementation of low-carbon city planning. At the same time, this component of a plan should reflect the needs and desires of different stakeholders as well as identify the goals that will be achieved (Berke and French, 1994). This component serves as an overview for local land use planning and also can examine the quality of low-carbon city plans. Goals are general expressions of a city's values but are abstract in nature. Objectives are more specific description of planning activities used to achieve the goals. Frequently, multiple objectives may be achieved before a goal is reached. Goals and objectives promote the formulation, adoption,

and implementation of effective land use strategies (Burby, 2005). The five goals and objectives are: (1) city carbon emission reduction targets; (2) promote a compact and multicenter urban form; (3) seek energy conservation and energy efficiency; (4) planning to address uncertainty; and (5) equity assistance and environmental justice.

Inter-organizational coordination

The inter-organizational coordination component of a low-carbon city plan identifies the demands that harmonize with adjacent jurisdictions, landowners, and agencies in order to generate a high quality land use plan. It recognizes that planning problems always extend beyond political boundaries and jurisdictions and that collaboration is a necessity to achieve low-carbon goals and objectives in common. This component serves as a framework for multiple level agencies, providing interdependent actions at the local level for plan implementation. It should solve existing or potential conflicts between stakeholders or multi-level agencies while examining the linkages to other action plans, for example, regional development plans or climate change action plans. It also requires stewardship to understand problems, to manage possible solutions and educate the public.

Policies, Tools and Strategies

This component is the heart of the local plan because it is the means for implementing a plan's goals and objectives and focusing directly on local jurisdictions' action (Berke and French, 1994). Policies, tools and strategies set forth

specific principles of low-carbon city design and development, and reflect clear commitments to guide decision-making in local governments (Kaiser and Godschalk, 1995). Strong policies draw on land use planning literature to identify tools and strategies that reach low-carbon plans effectively. The progress or achievement of policies, tools, and strategies should be able to be monitored or measured in order to update them rapidly. This component falls into six categories which reflect the five dimensions of city structural model. They are: (1) natural assets and open space; (2) urbanization development; (3) transportation system; (4) energy system; (5) economic system; and (6) research, education and communications.

Implementation and Monitoring

The implementation and monitoring component explains how an adopted local plan becomes an enduring instrument through implementation of the policies, tools and strategies component. This component assigns organizational responsibilities, priorities, financial commitment, and timelines to implement the local plan. It also measures the ability of a plan to achieve goals and objectives with timely updates.

There is an emerging trend in research literature that examines the influence of plan quality components on degree of success in plan implementation. At the local level, it is now well accepted that the Five Component Protocol is a powerful tool for local land use decision making and climate change impact mitigation and natural resources protection (Norton, 2005).

In conclusion, the conceptual model of low-carbon city land use planning illustrated in this chapter can help planners and decision makers determine the direction for their cities and communities to develop more sustainable land use patterns. The model identifies land use values, a low-carbon land use planning program and low-carbon city planning outcomes. Finally, this chapter sets forth the Five Component Protocol that planners need to use to evaluate the plans that are the basis for implementing low-carbon goals. The next chapter will introduce research methods that planners can utilize to transfer conceptual models to planning practice.

Chapter Four:

Research Methods

This chapter is composed of three sections. The first section focuses on defining the study area and selecting samples. The city comprehensive plans of the top fifty fastest growing population cities in the U.S. are the subjects of study in this thesis. The second section is a description of the indicators instrument, which describes 35 indicators and key words and how they will be used to evaluate plans quantitatively. The last section details data analysis procedures that show how data will be interpreted by using descriptive statistics analysis to assess the quality of the fifty plans in the sample. Results will be interpreted and examined in Chapter Five.

Section 4.1: Study Area and Sample Selection

The target population of this study comprises all U.S. cities, and sample units are local comprehensive plans of the top 50 fastest growing population cities in the U.S.. The list of these cities is attached in the Appendices (Appendix A). The city ranking data is cities shown on the City Mayors website based on the results of 2000 census data and the 2004 survey by the U.S. Census Bureau. Therefore, the ranking data are from 2000 to 2004, which are the most recent data available to the public at this time. The text-based data, local comprehensive plan documents, were downloaded from each city's official website. All comprehensive plans are available

for download. Figure 4.1 shows the locations of the top 50 fastest growing population cities, which are located in 14 states in total. It is clear to see that California possesses 14 of the fastest growth cities, Texas has 10, and Arizona has 9. The other 17 cities are located in 11 states on the East coast and in the Midwest; among these 11 states, seven states only have one fastest growth city. Most of them are located near the coastline, a location that is relatively more vulnerable and more sensitive to the effects of climate change.

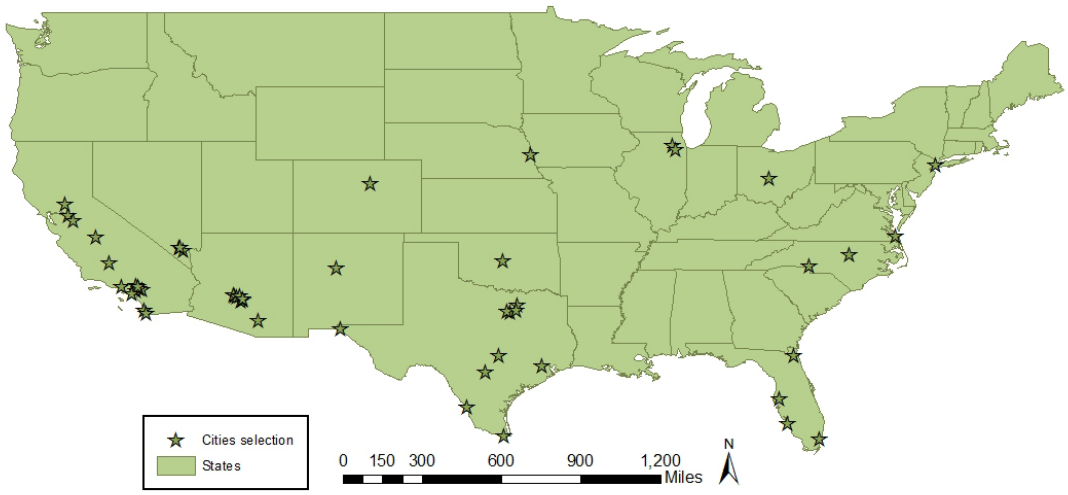

Figure 4.1: Locations of the Top 50 Fastest Growing Population Cities in U.S.

There are several reasons to select those 50 cities in this study. First, since population change and economic growth are the two main reasons behind the increase in the carbon problem since the 1980s (see, for example, Ratnakar, 2010), the top 50 fastest growing population cities, most of which are also having the most

rapid economic growth of all U.S. cities, provide ideal subjects to conduct this study. Second, the majority of researchers' studies in this field have excluded large cities that may affect their results. Large cities have a different context with so-called "fastest growing metro and micro areas" as named by the U.S. Census. This study will bridge this gap. Third, the 50 fastest growing U.S. cities have many more pressures and challenges dealing with population growth, urban development, and other problems (http://www.citymayors.com/gratis/uscities_growth.html, accessed March 2010). Finally, these cities also have more opportunities to mitigate and address climate change issues at the local level and serve as models nationally for other cities in the United States and worldwide (Bulkeley and Betsill, 2003).

This study uses local city comprehensive plans as units of analysis, primarily because these plans provide a fundamental review of local jurisdiction land use plans and decisions with a consistent format. Compared with other specific plans, such as local climate change plans, comprehensive plans have element types, policy instruments, and updating processes that serve as the basis for measuring plan quality. They also are important tools for driving collaborative efforts with other jurisdictions or organizations, accomplishing many of the goals of low-carbon city planning, and coordinating regional activities. More information of those 50 plans is listed in Appendix B.

Section 4.2: Indicators Instrument

Based on the Five Component Protocol, a total of 35 indicators will be used to scan the top 50 fastest population growing cities' plans. This section provides a definition of each indicator in low-carbon city plan quality evaluation, identification of key words used to mark an initial score, and comparison of the indicator from the literature review. Each indicator is scored on a scale of 0 to 2. Generally speaking, a score of "0" means an indicator is not mentioned in the plan at all, a score of "1" means that an indicator is considered but not fully described thoroughly, and a score of "2" means that the indicator is fully considered and fully detailed. The description of indicators measurement is in included the following section, and a description of the multiple data analysis procedures is in Section 4.3.

Section 4.2.1: Factual Basis Component

The factual basis component provides an empirical foundation for a low-carbon city plan in general. There are six indicators that address two issues mainly: background information and climate change awareness of a local jurisdiction.

(1) Population change and impacts: Population change causes changes in land use patterns and increased energy consumption. Population growth is the main reason for GHG emissions today. Existing and projected population change and impacts conditions can provide accurate background information to calculate a city's land

use capacity to motivate planners to select appropriate low-carbon strategies. If a plan lists human population growth trends and structure briefly, it will receive a score of 1. Furthermore, if the carrying capacity of a city is measured or a balance between population change and environmental capacity is discussed, the score is 2.

Key words: population expansion, population growth, population change

Definition resource: Stern, N. (2007). *The economics of climate change.* Page 12

(2) *Land development and sphere of influence:* The importance of land development and the resulting alterations in Earth's surface features should not be doubted now. This indicator describes fundamental environmental features within a city's boundary and areas with sphere of influence that may extend beyond the jurisdiction limit. If a plan describes basic features with maps, such as location, boundary, edge, and has a regionally spatial vision for development, it will be scored as 1. If the description is based on mapped sub-regional units, or an actual environmental management region, it can receive a score of 2. If a plan only contains basic setting information but no regional information, the score will be 0.

Key words: land development, regional development, subregional development

Definition resource: State of California. (2003). *State of California general plan guidelines.* Page 51

(3) *An inventory of existing resources and energy usage:* The foundation of the factual basis component is a resource inventory, especially energy usage inventory which should draw explicitly from the literature on climate science and

carbon-based energy consumption. If a general percentage of resources, including energy usage, is listed or mapped roughly, the score is 1. If a detailed inventory is presented to explain natural and cultural resources by using maps, the score is 2.

Key words: resource inventory, energy inventory

Definition resources: Brody, S.D. (2003). *Implementing the principles of ecosystem management through local land use planning.* Page 517

(4) *Climate change impacts and vulnerability:* Climate change is a key issue in building low-carbon city planning. It can profoundly influence the natural and built environment at multiple levels. This indicator measures whether a local plan considers existing and potential impacts of climate change and most vulnerable places and population. If a plan gives a draft description of climate impacts or vulnerability without specific places or climatic factors, it can be scored 1. If a plan identifies extreme climatic factors and places and populations that will be affected, it can get 2.

Key words: *Climate change impact, Climate change vulnerability, climatic factors*

Definition resources: Davoudi, S., Crawford, F., and Mehmood, A. (2009). *Planning for Climate Change: Strategies for Mitigation and Adaptation for Spatial Planners.* Page 5

(5) *Recognition of greenhouse gas (CO_2) emission:* GHG emissions are the main contributor to climate change and global warming. It is necessary to highlight knowledge of GHG emissions in low-carbon city planning. This item measures whether a local jurisdiction considers greenhouse gas or CO_2 emissions and global

warming. If a local plan contains the concept of greenhouse gas emissions, it receives 1. If a plan can establish the category of main drivers and contribution sources of GHG in a local jurisdiction area or region, it will get a score of 2.

Key words: GHG emission, CO_2 emission, global warming

Definition resources: Davoudi, S., Crawford, F., and Mehmood, A. (2009). *Planning for Climate Change: Strategies for Mitigation and Adaptation for Spatial Planners.* Page 8

(6) *Knowledge of ozone layer depletion:* Chlorine and bromine exhaust the ozone, which shields the earth's surface from ultraviolet radiation. The main resources of man-made chemicals for ozone layer depletion come from air conditioners, refrigerators, aerosol sprays, foamed plastics and fire extinguishers. If the conception of ozone layer depletion is mentioned, the plan can get 1. If the sources of main ozone depleting substances and their consequences are discussed, the plan will be scored as 2.

Key words: ozone, ozone layer depletion

Definition resources: Hartmann et al., (2000). *Can ozone depletion and global warming interact to produce rapid climate change?* Page 1412

4.2.2: Goals and Objectives Component

As Section 3.3 mentioned, this component contains five indicators and describes the needs and desires of different stakeholders as well as identifies the goals which can be achieved in low-carbon city planning.

(7) *City carbon emission reduction target:* A long-term carbon emission reduction target should be defined in this indicator, which will help to support policies at the federal, state, and local levels. Clear city-wide carbon reduction strategies and process will result in reducing GHG emissions at least 80 percent below 1990 levels by 2050. If a plan identifies long-term reduction targets with short- and medium-term goals at multiple levels, it can be scored as 2. If it only generally identifies a target without specific strategies and process, it will receive a score of 1.

Key words: emissions reduction goal; emissions reduction target

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 12

(8) *Promote a compact and multicenter urban form:* Compact and multicentered development patterns encourage people and goods to move within a community by walking, bicycling or using public transportation instead of automobiles. This indicator measures whether a local plan encourages high density communities and public transit systems to reduce the distance between uses. If a plan identifies the development edges of an urban area, residential densities and compact regional

development to reduce greenhouse gas emissions, it can receive a score of 2. If it only generally describes the utilization of a public transportation system to reduce GHG emissions, it can get 1.

Key words: compact, high density, multi-center, smart growth

Definition resources: APA. (2008). Policy guide on planning & climate change. Page 21

(9) *Seek energy conservation and energy efficiency:* The goal of this indicator is to encourage research and development of energy conservation management and maximize renewable energy potential. This indicator not only helps address climate change, but it can also form the basis for new economic opportunities. It measures whether local jurisdictions strategically reduce greenhouse gas emissions and measures whether local jurisdictions set a goal to reduce vulnerability to the effects of climate change, e.g., flooding and drought. If a plan contains the description of a relationship between energy conservation and renewable energy and GHG emissions, it can get a score of 1. If a plan has detailed strategies to reduce GHG emissions through energy efficiency, including renewable energy, it can get a score of 2.

Key words: energy conservation, renewable energy, energy efficiency

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 32

(10) *Planning to address uncertainty:* This item is particularly subject to uncertainties, for example, certain changes occurring at the global level, or unknown costs for

local jurisdictions when building low-carbon cities. However, this is also an important factor to determine where action should begin. If a plan identifies future uncertainties at multiple levels, it can be given a score of 1. If a plan builds consensus on a direction for responding to future uncertainties and provides a framework for actions, it will get a score of 2.

Key words: future uncertainties, future unknown

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 13

(11) Equity assistance and environmental justice: This indicator is an important goal for low-carbon city strategic management. Local planning may be concerned with inequitable distribution of the benefits. This item measures whether a city set a goal for the fair treatment and meaningful involvement of all people regardless of race, color, nationality, or income with respect to local land use development, implementation, and enforcement of environmental laws, regulations, and policies. If a plan detailed, identified, and listed the need for social equity and a balance conflicting demands between different classes of people, it can get a score of 2. If only general described, it can get a score of 1.

Key words: equity, environmental justice

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 17

Section 4.2.3: Inter-organizational Coordination Component

This component contains three indicators which briefly require coordinating with other organizations and public participation.

(12) Inter-organizational coordination within the jurisdiction: This indicator first identifies the key stakeholders, organizations, government agencies within a local plan quality measurement. Then it helps local jurisdictions identify each responsibility and build a network for stakeholders and organizations. If a plan lists major stakeholders and organizations with their interests, it will be scored as 2. If a plan only identifies stakeholders without detailing how they are to work together, it will receive a score of 1.

Key words: stakeholders, organizations, inter coordination

Definition resources: Brody, S.D. (2003). *Implementing the principles of ecosystem management through local land use planning.* Page 519

(13) Coordination with surrounding jurisdictions: This indicator measures the coordinating capability of a local jurisdiction with adjacent jurisdictions and larger spatial scale (such as state, regional, federal or even international level groups) organizations and agencies. Many planning problems, particularly cross-boundary environment issues or global climate problems, need to be solved together. If a plan lists organizations and government agencies at multiple levels to coordinate with and identifies problems which need to be solved with those organizations or

other jurisdictions, it will get a score of 2. If only one sentence or a few words are mentioned, it will get a score of 1.

Key words: adjacent jurisdictions, surrounding jurisdictions, multiple levels organizations, multiple levels agencies

Definition resources: Brody, S.D. (2003). *Implementing the principles of ecosystem management through local land use planning.* Page 519

(14) Public education program and environmental stewardship: This indicator implies that a local jurisdiction coordinates with its citizens. This indicator measures whether a local plan contains an educational system for citizens, and more important, for decision-makers and facilitators, to understand the substance of environmental quality and low-carbon city planning. If a plan sets systematic strategies to gather all citizens and groups into low-carbon city planning, it can get a score of 2. If it only describes public participation and/or public hearings, but does not mention educational methods, it can receive a score of 1.

Key words: public education program, public outreach, environmental stewardship

Definition resources: Burby, R. J. (1998). *Cooperating with nature: Confronting natural hazards with land-use planning for sustainable communities*. Page 208

Section 4.2.4: Policies, Tools and Strategies Component

This component sets forth a series of specific principles for low-carbon city planning and reflects the dimensions of a low-carbon city structure model. There are 17 indicators in six categories, which serve as the heart of this protocol. If a plan provides the definition of the indicators and describes the approaches to implement it, it can receive a score of 2. If it only has a brief definition without specific strategies, it will receive a score of 1. If a plan never mentions the term of an indicator, the score will be 0.

Natural Assets and Open Space

(15) Creation of conservation zones or protected areas: This policy considers protection of important natural assets and open areas in local development in order to maintain their roles as 'carbon sinks'. A plan should provide maps and lists of those areas and how to protect them.

Key words: natural conversation area, natural protect area, conversation easement

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 23

(16) Green infrastructure system: This item is a new concept emerging in recent years. It means using natural systems to enhance overall environmental quality and provide utility and technical services. The natural system includes urban

forests, parks and open spaces, natural drainage systems, and so on. Generally speaking, green infrastructure techniques use soils and vegetation to infiltrate, evapo-transpirate, and/or recycle storm water runoff.

Key words: green infrastructure

Definition resources: http://www.epa.gov/greeningepa/glossary.htm [Accessed Sept. 2010]

(17) *Low impact development:* This item refers to a sustainable landscaping approach that can be used to protect and restore natural systems, especially the water system. Low impact development minimizes impervious surfaces and maximizes open or green space that is consistent with other land use policies such as controlling urban sprawl and promotes efficient land use patterns.

Key words: low impact development, low impact design

Definition resources: http://www.epa.gov/greeningepa/glossary.htm [Accessed Sept. 2010]

Urbanization Development

(18) *Mixed use and compact development:* Mixed-use development is well accepted now in urbanization development. Mixed use and compact urban pattern reduce travel distance to make alternative travel modes more feasible, like walking or biking. It also encourages mix land use so that working, shopping, entertainment and other destinations are near homes.

Key words: mixed use, compact development

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 19

(19) *Infill development and reuse of brownfields:* This indicator promotes redevelopment of existing neighborhoods. Infill development *and reuse of brownfields* should be given a high priority in the local land use planning process because a large amount of land in cities now needs to be infilled or redeveloped. This indicator encourages maintaining and improving existing infrastructure, which is an effective way to achieve energy efficiency.

Key words: infill development, brownfield, redevelopment

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 21

(20) *Pedestrian/resident-friendly, bicycle-friendly, transit-oriented community design :* This policy helps to build a more attractive, livable and energy-saving community. Low-carbon cities should encourage more communities with such design to minimize traffic and carbon emission impacts from travelling.

Key words: pedestrian-friendly design, livable community, walkability, transit-oriented design, TOD, bicycle-friendly design

Definition resources: Tang, Z. (2010). *Eco-City and Green Community: The Evolution of Planning Theory and Practice*. Page 34

Transportation System

(21) *Highly-connected street patterns and community design:* Highly-connected street patterns provide all modes of transit, but focus on walking and biking. Such street systems facilitate appropriate locations for bicycle and pedestrian routes to avoid automobile involvement. This indicator requires highly-connected street, transit, bicycle and pedestrian networks in neighborhoods, communities and regions by using a community design and development review process. Routes for these alternative transportation modes should be located and provided for through the planning and subdivision processes.

Key words: highly-connected street patterns, bicycle and pedestrian network

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 27

(22) *Multi-modal transportation corridor improvements:* Multi-modal transportation corridors create different travel choices for people and encourage them to use their time and money more efficiently to reduce GHG emissions. Financial tools can be used to encourage travelers to switch to public transportation systems to reduce congestion. Moreover, this indicator is flexible to take advantage of newer and greener travel choices in the future.

Key words: Multi-Modal Transportation Corridor

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 29

(23) *Transportation demand* management (TDM): This policy focuses on changing travel behavior of human beings, such as trip rates, trip length, travel mode, and so

on. It can reduce the number of automobile trips and increase vehicle options. Most TDM strategies reduce GHG emissions through shortened trips or shifting trips from peak periods to less congested periods. This indicator can achieve public goals such as reduced traffic congestion, improved air quality, and decreased reliance on non-renewable energy consumption, in addition to reducing greenhouse gas emissions.

Key words: transportation demand management, TDM

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 30

Energy System

(24) Facilitating local renewable sources: With the rapid development of renewable energy today, local renewable energy systems can help reduce dependence on carbon-based energy sources. Therefore, identification of sites for local energy generation becomes more significant in the city planning process. Some cities own perfect sites for wind or geothermal energy. Other cities may be desirable for solar energy or even nuclear energy. If a local plan includes the locations of energy production, their impacts on the environment and neighborhood should be assessed and zoned for particular uses.

Key words: local renewable sources, local renewable energy

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 32

(25) *Building codes for energy and e*nergy efficiency: This indicator measures whether building codes are enforced to keep the reliability of the building standards well as meet energy efficiency goals. Leadership in Energy and Environmental Design (LEED) provides green building design, construction, operations and maintenance solutions to reduce the local carbon footprint and GHG emissions.

Key words: building codes for energy efficiency, LEED

Definition resources: http://www.energycodes.gov/why_codes/ [Accessed Sept. 2010]

(26) *Zero waste/high recycling strategy:* Zero waste is a philosophy that encourages the redesign of resources so that all products can be recycled and reused in life cycles. This indicator refers to use of a new recycling method to minimize non-renewable waste and energy loss.

Key words: zero waste, high recycling, waste minimization, waste reduction

Definition resources: http://www.zerowaste.org/case.htm [Accessed Sept. 2010]

Economic System

(27) *Funding for energy efficiency and conservation:* Since the higher initial costs of renewable energy facilities often prevent their use and are widespread, some federal or state agencies provide funding to help local jurisdictions reduce or offset initial costs. This indicator is an important financial tool for reducing

dependence on carbon-based energy and the greenhouse gas emissions from these energy usages.

Key words: energy efficiency funds, conservation grants, loans, incentive program

Definition resources: APA. (2008). *Policy guide on planning &* climate change. Page 33

(28) Establish cap and trade system/ carbon tax: This indicator achieves public goals by using the power of private market regulations. This is a leading approach to implement nationwide carbon emission reduction targets which serves as a background on the local jurisdiction's climate-related activities. Local jurisdictions need to develop strategies to address this issue.

Key words: cap and trade, carbon tax

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 35

(29) Supporting green business/green jobs: According to the United Nations Environment Program (UNEP), the definition of a green job is "working in agricultural, manufacturing, research and development (R&D), administrative, and servicing activities that contribute(s) substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution." (UNEP, 2008).

Key words: green business, green jobs

Definition resources: UNEP. (2008). *Green Jobs: Towards decent work in a sustainable, low-carbon world.* Page 33

Research, Education and Communications

(30) Public participation program: This item encourages and ensures public participation in local planning decision making processes. Public participation provides checks and balances in the process and improves the quality of decisions. A local government should involve public participation as early as possible in order to save time and cost.

Key words: public participation, public education, citizen

Definition resources: Bulkeley, H., and Mol, A.P.J. (2003). *Participation and environmental governance: consensus, ambivalence and debate.* Page 143

(31) Education for decision makers and stakeholders: This indicator measures whether public and private sector decision-makers are informed about the knowledge of GHG emissions, climate change research, and how local jurisdiction affects global issues. If a plan includes strategies for public interaction and education for decision makers and stakeholders, it can get a 2. If a plan only has the concept, it gets 1.

Key words: education for stakeholders, education for decision makers

Definition resources: APA. (2008). *Policy guide on planning & climate change.* Page 33

Section 4.2.5: Implementation and Monitoring Component

This component includes four indicators to explain how a local low-carbon city plan becomes an enduring instrument.

(32) *Highlight implementation priorities for action plans:* This indicator is an important one for a local jurisdiction to measure the effectiveness of its policies, tools and strategies. In this item, a clear and reliable time line should be listed and meanwhile, a high priority on developing low-carbon city strategies should be provided to get a score of 2. If a plan lacks the essential tables or figures to address this item but has only a few words to describe it, the score will be 1.

Key words: implementation priority

Definition resources: Tang et al., (2010). *Measuring local climate change response capacity and bridging gaps between local action plans and land use plans.* Page 80

(33) *Make financial/budget commitment in Capital Improvement Plans (CIP):* A Capital Improvement Plan (CIP) is a short-term plan which identifies capital projects and equipment purchases and provides a financing schedule of the plan. Usually it is used in local planning projects. It also serves as a public relations and economic development tool. If a plan emphasizes using CIP methods and identifies reliable financial support for plan implementation, it will be scored as 2. If a plan only mentions the concept of CIP, it will be scored as 1.

Key words: capital improvement plan, CIP

Definition resources: Tang et al., (2010). *Measuring local climate change response capacity and bridging gaps between local action plans and land use plans.* Page 80

(34) *Identify roles and responsibilities among sectors and stakeholders in sustainability:* This item measures the ability of a local jurisdiction to identify and assign responsibilities to stakeholders and staff. If a plan only uses a few sentences to describe major agencies' responsibilities for the plan's implementation, it can be scored as 1. If each agency's responsibilities and every department's roles are listed or identified, it can be scored as 2.

Key words: roles of stakeholders, responsibilities of stakeholders

Definition resources: Tang et al., (2010). *Measuring local climate change response capacity and bridging gaps between local action plans and land use plans.* Page 80

(35) *Make continuously monitor, evaluate and update:* A city needs to continuously monitor development, evaluate the status, and update comprehensive plans. This indicator measures the capability of a local plan to improve the quality in the future. If a plan provides procedures for updating local comprehensive plans reports, it will get a score of 2. If a plan sets a time or procedure to regularly assess plan effectiveness, it will get a score of 2. If a plan mentions this point with no details, it will be scored as 1.

Key words: continuous monitoring, continuous update

Definition resources: Brody, S.D. (2003). *Implementing the principles of ecosystem management through local land use planning.* Page 536

This section has identified every indicator's definition, key words and definition resources in each component. The next section will introduce the procedures to measure the plans by using the Five Components Protocol.

Section 4.3: Data Analysis Procedures

This study will use the Five Component Protocol to measure and evaluate the plan documents. It includes two phases of descriptive statistics analysis to assess the quality of the sampled local land use plans and measure the plan quality of local jurisdictions (Brody, 2003; Tang et al., 2011). The idea of the protocol development is that each plan is evaluated by scanning all elements to assess whether it has addressed 35 indicators, which was explained and described in Section 4.2. This study assumes each component is an equal weight to avoid inconsistency.

The first stage of the measurement procedure includes the following four steps:

The first step is to assign the scores for each indicator for each plan reviewed. Each item is desighated on a 0-2 ordinal scale, where "0" means not included, "1" means brief description but not detailed, and "2" means fully detailed with tables, figures, or maps. For example, the first indicator, population change and impacts,

can be either mapped, catalogued or both to get a score of 2. Otherwise, the score is 1. If this item is not mentioned at all, the score is 0.

The second step is to sum a total score within each component. The range of the component scores depends on the number and value of the indicators. For example, in the factual basis component, there are six indicators where the range of possible scores is 0 to 12. In another example, in the policies, tools and strategies component, there are 17 indicators, and thus the score range is 0 to 34.

The third step is to standardize the scores for each component. The method is to divide the total component score of each component by the maximum score it could receive. Then the result is multiplied by 10 to ensure that the standardized score range is 0 to 10. For example, there are total of six indicators in the factual basis component, and the maximum score for each indicator for one city in the component is 2. Therefore the maximum score for the component is 2*6=12. If a city received X in this component, then the total standardized score is [(X/2*6)*10].

The fourth step is adding each of the five component scores together to get the total plan quality score. Once plans are coded by using the low-carbon city plan protocol, an overall plan quality can be measured. The possible total scale range for measuring a local low-carbon city plan quality is 0 to 50 (5 components X 10 maximum score for each component).

The second stage analysis involves measuring each indicator's quality score against the component performance. Indicator performance contains two perspectives: coverage score and depth score. Coverage score means the percentage

of plans that mention an indicator which measures the proportion of plans that address the indicator. Depth score means the percentage of an indicator addressed in a plan which measures the level of detail is stated or the strength of a specific indicator.

To maintain reliability, every indicator was tested three times to reduce personal bias and other influencing factors in measurement and judgment. The first time evaluation is using a key word search approach to get an initial score for each indicator. Each plan was scanned by the key words defined above. After all plans were scanned by the first indicator, it was moved onto the next indicator. The second test went back to the context to make sure the score is correct. The third time was to read the whole document briefly. This procedure can verify the initial scores to reach the final evaluated score for each indicator.

The research methods and procedures stated above fully address the two research questions brought up in the first chapter. The next chapter will present the findings from the analysis process and will answer the questions quantitatively. After then, a series of planning recommendations will be given in order to achieve a model for low-carbon city development at the local level.

Chapter Five:

Results

This chapter will highlight experimental findings by evaluating the 50 plans against the Five Component Protocol, and thereby answering the two research questions: (1) how well do the fastest growing cities in U.S. implement low-carbon principles in their local comprehensive land use plans? (2) How can local land use plans be improved to achieve the goal of low-carbon cities? Through results analysis, this chapter will attempt to provide opportunities to strengthen local planning frameworks and threatens to weaken the capabilities of local jurisdictions to achieve low-carbon city planning. The chapter starts with an assessment of total low-carbon city plan quality and plan component scores. Then the chapter analyzes indicator-based scores, including item coverage percentage and item depth percentage scores, for the sample of plans included in this study.

Section 5.1: Overview of Low-carbon City Plan Quality

The descriptive results for the first stage of the measurement are total quality and component performance. The analysis provides an overall assessment of how well the 50 local jurisdictions are adopting low-carbon principles in their local comprehensive land use plans. In Table 5.1, it is clear to see that the mean of the total scores for the 50 plans is 31.97, which is 63.94 percent out of total possible scores,

indicating that local jurisdictions have undertaken some level of effort to achieve a low-carbon city at the local level. In addition, there are large variations (STD = 8.03) in the quality of sample plans. The lowest score is 14.49 and the highest score is 46.99. Such result indicates that cities have various capacities to address the carbon problem in their comprehensive plans.

Table 5.1: Descriptive Statistics for Total Quality and Components Performance

Components [a]	Number of variables	Minimum	Maximum	Mean	Std. Dev.
1. Factual basis	6	0.83	10.00	5.73	2.45
2. Goals and objectives	5	1.00	9.00	5.30	2.26
3. Inter- organizational coordination	3	3.00	10.00	8.53	1.63
4. Policies, tools and strategies	17	2.06	8.82	5.51	1.70
5. Implementation and monitoring	4	1.25	10.00	7.02	2.17
Total [b]	35	14.49	46.99	31.97	8.03

(a: component score range: 0 – 10; b: total score range: 0 – 50)

The goals and objectives component receives the lowest score (Mean = 5.30), which means that there is a shortage of local governments that tend to set goals for low carbon cities. In contrast, the inter- organizational coordination component scores are highest with a mean of 8.53 on a scale of 0-10, indicating those governments recognized the importance of coordination at multiple levels and are willing to collaborate with other cities to achieve low carbon goals and objectives. However,

this high score may imply that an inter-governmental coordination element is required in all plans.

Table 5.2: Plan Components Scores and Total Scores in Each City

Rank (Based on population increase)	City	State	Factual basis	Goals and objectives	Inter-organizational coordination	Policies, tools and Strategies	Implementation and monitoring	Total
1	Los Angeles	CA	6.67	8.00	10.00	4.71	8.75	38.12
2	New York	NY	8.33	9.00	10.00	7.06	7.50	41.89
3	San Antonio	TX	3.33	3.00	10.00	5.88	5.00	27.22
4	Phoenix	AZ	8.33	8.00	8.33	6.18	6.25	37.09
5	Houston	TX	4.17	2.00	5.00	2.06	5.00	18.23
6	Fort Worth	TX	6.67	8.00	8.33	7.06	7.50	37.56
7	Charlotte	NC	4.17	3.00	6.67	5.00	6.25	25.08
8	San Diego	CA	9.17	9.00	8.33	7.35	8.75	42.60
9	Raleigh	NC	9.17	9.00	10.00	8.82	10.00	46.99
10	Henderson	NV	4.17	3.00	8.33	3.24	6.25	24.99
11	Las Vegas	NV	8.33	7.00	10.00	7.35	10.00	42.69
12	Sacramento	CA	9.17	9.00	10.00	8.53	8.75	45.45
13	Jacksonville	FL	7.50	5.00	10.00	6.47	7.50	36.47
14	Mesa	AZ	5.00	4.00	8.33	3.82	3.75	24.91
15	Gilbert town	AZ	7.50	5.00	8.33	4.71	6.25	31.79
16	Chandler	AZ	4.17	4.00	8.33	5.59	6.25	28.34
17	North Las Vegas	NV	4.17	6.00	8.33	3.82	6.25	28.57
18	Stockton	CA	9.17	9.00	10.00	7.06	7.50	42.73
19	Irvine	CA	2.50	4.00	8.33	4.71	2.50	22.04
20	Riverside	CA	10.00	9.00	10.00	5.88	8.75	43.63
21	Chula Vista	CA	7.50	7.00	10.00	6.76	6.25	37.51
22	Bakersfield	CA	5.00	1.00	10.00	2.94	6.25	25.19
23	Rancho Cucamonga	CA	10.00	7.00	10.00	8.53	10.00	45.53

24	Fresno	CA	2.50	5.00	6.67	6.18	7.50	27.84
25	Albuquerque	NM	6.67	3.00	10.00	5.59	7.50	32.75
26	Fontana	CA	5.83	4.00	8.33	5.88	7.50	31.55
27	Arlington	TX	1.67	2.00	5.00	4.41	3.75	15.16
28	Tucson	AZ	5.00	5.00	10.00	4.41	7.50	31.91
29	Laredo	TX	2.50	3.00	8.33	2.35	3.75	19.94
30	El Paso	TX	5.83	5.00	10.00	5.88	6.25	32.97
31	Plano	TX	6.67	6.00	8.33	4.41	1.25	26.66
32	Dallas	TX	3.33	6.00	8.33	5.88	6.25	29.80
33	Peoria	AZ	5.83	4.00	10.00	8.24	8.75	36.82
34	Aurora	IL	0.83	4.00	3.33	3.82	2.50	14.49
35	Modesto	CA	5.00	5.00	6.67	6.47	6.25	29.39
36	Corona	CA	6.67	3.00	6.67	5.00	7.50	28.83
37	Joliet	IL	3.33	2.00	5.00	4.41	10.00	24.75
38	Oklahoma	OK	4.17	4.00	6.67	3.53	6.25	24.61
39	Columbus	OH	2.50	3.00	8.33	2.94	7.50	24.27
40	Brownsville	TX	5.83	7.00	10.00	6.76	8.75	38.35
41	Cape Coral	FL	2.50	4.00	8.33	4.41	5.00	24.25
42	Austin	TX	5.00	6.00	10.00	5.59	10.00	36.59
43	Scottsdale	AZ	4.17	4.00	8.33	5.88	10.00	32.38
44	Moreno Valley	CA	6.67	6.00	8.33	2.94	7.50	31.44
45	Miami	FL	1.67	3.00	10.00	3.53	8.75	26.95
46	Omaha	NE	9.17	9.00	10.00	7.65	10.00	45.81
47	Virginia Beach	VA	9.17	6.00	8.33	6.47	3.75	33.72
48	Tampa	FL	5.83	5.00	10.00	7.35	8.75	36.94
49	Glendale	AZ	5.83	4.00	8.33	5.00	8.75	31.92
50	Aurora	CO	8.33	8.00	6.67	7.35	8.75	39.10

As shown in Table 5.1, mean scores for all five plan components are higher than 5 on a scale of 0 to 10, indicating that cities have fairly good knowledge of low carbon city planning, making general goals, taking some level of action and implementing them within a well organized framework. Table 5.2 shows that a total of 28 jurisdictions received scores lower than the mean (31.97), and a total of 11

jurisdictions received scores lower than half of the maximum possible score (50). In these 50 cities, there are 9 cities with scores higher than 40. The highest three are the City of Raleigh, NC, (46.99), City of Omaha, NE, (45.81) and City of Rancho Cucamonga, CA, (45.53). Nineteen cities' plan quality scores are in the range of 30 to 40, 18 cities' scores are in the range of 20 to 30, and only 4 cities received a score of less than 20. The last cities that have the lowest scores are the City of Huston, TX, (18.23), City of Arlington, TX, (16.83) and City of Aurora, IL, (14.49). Specific analysis within each plan component will be discussed in Section 5.2 in more detail.

Section 5.2: Analyzing Indicators within Each Plan Component

The results from the second stage of analysis provide each indicator's quality score against the component performance.

Section 5.2.1: Factual Basis Scores

Table 5.3 represents indicator coverage scores and depth scores of the factual basis component. There are a total of six indicators, four of which are addressed pervasively in the 50 plans reviewed. Most (98%) of the cities identify land development and sphere of influence and 86% of those plans provide detailed data or maps. Similarly, most (92%) plans listed and described population change and impact and 68% measured the balance between population change and environment capacity.

In the inventory of existing resources and energy usage, 82% of plans addressed this issue but only 65% of them addressed it thoroughly. For the last indicator in this component, knowledge of ozone layer depletion, 72% plans mentioned it and 59% gave the reason why it is important to consider.

Table 5.3: Factual Basis Component Indicator Performance

Indicators	Coverage (%)	Depth (%)
(1) Population change and impacts	92%	68%
(2) Land development and sphere of influence	98%	86%
(3) An inventory of existing resources and energy usage	82%	65%
(4) Climate change impacts and vulnerability	36%	27%
(5) Recognition of greenhouse gas (CO_2) emission	48%	39%
(6) Knowledge of ozone layer depletion	72%	59%

Two of the indicators are addressed rarely and minimally in the 50plans reviewed. Climate change impacts and vulnerability only obtained 36% for coverage scores and 27% for depth scores. Recognition of greenhouse gas (CO_2) emissions only received 48% for coverage scores and 39% for depth scores. The majority of plans focused on traditional issues, such as providing detailed land use maps, listing population trends, and identifying compounds which cause ozone depletion reduction. However, other important elements for understanding low-carbon city planning

received lowest scores in both coverage and depth scores, such as climate change awareness and recognition of GHG emissions.

Section 5.2.2: Goals and Objectives Scores

The results in Table 5.4 show that the majority of plans include broad goals to seek energy conservation and energy efficiency, and promote a compact and multicenter urban form. Most (92%) plans have the goal of seeking energy conservation and energy efficiency, and 75% have specific strategies to achieve it; 88% of the plans promote compact city planning, and 78% of them provide approaches. Only 66% of the plans include the goal of equity assistance and environmental justice, and less than half (47%) provide specific strategies. Moreover, relatively fewer plans address more specific goals and objectives involved directly in low-carbon city planning, such as setting up a city carbon emission reduction target (36%, 29%) and planning to address uncertainty. Fifty percent of cities' plans mentioned planning to address uncertainty, but only 36% of them identify what uncertainty is and how to deal with it in the future. A city carbon emission reduction target has been increasingly identified as an important item for building low carbon cities (Ho and Fong, 2007), but only 36% of plans contain this goal and 29% provide detailed strategies. These results imply that the sample plans only concentrate on general goals in city planning, but they lack the integration of specific objectives related to building low-carbon cities.

Table 5.4: Goals and Objectives Component Indicator Performance

Indicators	Coverage (%)	Depth (%)
(7) City carbon emission reduction target	36%	29%
(8) Promote a compact and multicenter urban form	88%	78%
(9) Seek energy conservation and energy efficiency	92%	75%
(10) Planning to address uncertainty	50%	36%
(11) Equity assistance and environmental justice	66%	47%

Section 5.2.3: Inter-organizational Coordination Scores

Table 5.5 reveals that there is a moderate range of coverage scores (90% - 100%) and depth scores (75% - 91%). Overall, there are three indicators in this component, and none of them was addressed "rarely." Compared to other plan components, inter-organizational coordination scores are strong in both coverage and depth. Only two Illinois cities, the City of Aurora and City of Joliet, do not address coordination with surrounding jurisdictions (96% for coverage scores and 90% for depth scores), and both of them received very low total quality scores. All of the sample cities reveal a strong commitment toward coordination within the jurisdiction as well (100% for coverage scores and 91% for depth scores). Meanwhile, 90% of cities established a public education program and encourage environmental stewardship in their plans and

75% of them do it thoroughly. However, it should be clear that indicators in this component are almost mandatory, which raises the indicator quality scores.

Table 5.5: Inter- organizational Coordination Component Indicator Performance

Indicators	Coverage (%)	Depth (%)
(12) Inter-organizational coordination within the jurisdiction	100%	91%
(13) Coordination with surrounding jurisdictions	96%	90%
(14) Public education program and environmental stewardship	90%	75%

Table 5.6: Policies, Tools and Strategies Component Indicator Performance

Indicators	Coverage (%)	Depth (%)
Natural Assets and Open Space		
(15) Creation of conservation zones or protected areas	82%	64%
(16) Green infrastructure system	20%	18%
(17) Low impact development	40%	33%
Urbanization Development		
(18) Mixed use and compact development	100%	77%
(19) Infill development and reuse of brownfields	96%	89%
(20) Pedestrian/resident-friendly, bicycle-friendly, transit-oriented community design	90%	73%
Transportation System		
(21) Highly-connected street patterns and community design	96%	83%
(22) Multi-modal transportation corridor improvements	82%	72%
(23) Transportation demand management (TDM)	64%	58%

Energy System		
(24) Facilitating local renewable sources	78%	66%
(25) Building codes for energy and energy efficiency	62%	57%
(26)Zero waste/high recycling strategy	78%	64%
Economic System		
(27) Funding for energy efficiency and conservation	50%	38%
(28) Establish cap and trade system/ carbon tax	4%	2%
(29) Supporting green business/ green jobs	18%	17%
Research, Education and Communications		
(30) Public participation program	100%	84%
(31) Education for decision makers and stakeholders	56%	43%

Section 5.2.4 Policies, Tools and Strategies Scores

The results for the policies, tools and strategies component show that there are large variations among the 17 indicators. Table 5.6 shows that coverage scores are from 4% to 100% and depth scores are from 2% to 89%. Moreover, there are significant variations among the six different categories. Overall, sample plans did very well in traditional policies, like mixed use and compact development, infill development, and a public participation program. However, other regulations, such as green infrastructure systems or supporting green business/ green jobs are less represented. The result also shows that tools focusing on new approaches like establishing a cap and trade system/ carbon tax or low impact development which

may gain significant achievements in building low-carbon cities are not commonly found in the sample comprehensive plans.

Natural Assets and Open Space. A total of 82% of plans address the indicator of creation of conservation zones or protected areas and 64% of them do it thoroughly. The other two indicators in this category are green infrastructure system and low impact development. Both of them are minimally addressed. Only 20% of cities include the concept of green infrastructure and 18% of them offer specific policies to achieve it. Forty percent of plans cover low impact development or low impact design and only 33% of them provide more detailed information.

Urbanization Development. In this category, there are three indicators, all of which are pervasively and thoroughly addressed. Mixed use and compact development are addressed in 100% of the plans and thoroughly discussed in 77%. Similarly, infill development and reuse of brownfields are given to habitat protection/restoration (96% for coverage score, 89% for depth score) and pedestrian/resident-friendly, bicycle-friendly, transit-oriented community design (90% for coverage score, 73% for depth score). This category includes traditional mainstream policies which play an important role in building low-carbon cities. Most of those traditional policies are mandatory and contribute high scores in this component.

Transportation System. There are also three indicators in this category. The majority of sample plans addressed these indicators with detailed information. 96% of the plans cover highly-connected street patterns and community design, and this

indicator is thoroughly discussed in 83%. Similarly, levels of attention are given to multi-modal transportation corridor improvements (82% for coverage score, 72% for depth score) and transportation demand management (64% for coverage score, 58% for depth score). There are also traditional policies, tools and strategies and contribute high scores.

Energy System. Similar to indicators in the transportation category, facilitating local renewable sources received 78% for a coverage score and 66% for a depth score; building codes for energy and energy efficiency received 62% for a coverage score and 57% for a depth score; and zero waste/high recycling strategy received 78% for a coverage score and 64% for a depth score.

Economic System. Half of the sample plans (50%) supply funding for energy efficiency and conservation, but only 38% of them state how to do that. Only 18% of cities support green business/ green jobs in their comprehensive plan, and 17% of them offer more detailed information. Only two cities, the City of New York and the City of Brownsville, mention the cap and trade system/ carbon tax with no details; therefore the coverage score of this indicator is 4% and depth score is 2%.

Research, Education and Communications. There are only two indicators in this category. Table 5.6 shows 100% cities set up public participation programs for citizens, and 84% of them supply specific policies, tools and strategies to implement. However, only 56% of the cities have education for decision makers and stakeholders, and the depth score is 43%. This result implies that cities supposed decision makers and stakeholders were well informed before the plan was made.

Section 5.2.5: Implementation and Monitoring Scores

Table 5.7: Implementation and Monitoring Component Indicator Performance

Indicators	Coverage (%)	Depth (%)
(32) Highlight implementation priorities for action plans	88%	71%
(33) Make financial/budget commitment in Capital Improvement Plans (CIP)	84%	75%
(34) Identify roles and responsibilities among sectors and stakeholders in sustainability	72%	54%
(35) Make continuously monitor, evaluate and update	100%	81%

The results in this plan component measure a local jurisdiction's capability to implement its plan, instead of the plan being implemented after adoption. Table 5.7 proves that there is substantial variation in coverage scores (62–88%) and depth scores (54–81%). There are four indicators in total and all of them are pervasively and relatively throughout. A total of 88% plans highlight implementation priorities for action plans and 71% of them identified priority levels for different action plans. 84% plans make financial/budget commitments in Capital Improvement Plans (CIP) and 75% of them provide detailed information. The majority of cities (72%) identify roles and responsibilities among sectors and stakeholders in sustainability, while 54% of them do it thoroughly. All of the plans mention continuously monitoring, evaluating and updating, and 81% do it thoroughly. The scores of the implementation component are relatively high because they are almost always

mandatory elements of a comprehensive plan. These indicators, along with policies, tools and strategies component, together can ensure the plan actually comes to practice and informs the public in a straightforward manner.

Chapter Six:

Discussion and Conclusion

Based on the results above, this chapter starts with the findings of critical issues in current comprehensive plans. Overall, local jurisdictions have been able to establish effective planning frameworks, but have failed to incorporate specific low-carbon city principles into their frameworks. Based on these findings, cities can improve the factual basis of the plans, adopt more specific goals and policies, and expand the planner's toolbox to achieve a higher quality of low-carbon city planning. Theoretical and policy-making contributions will be stated in the next section. Generally, this study has extended the conceptualization of what is a low-carbon city and how to build it. It also makes contributions to convert planning theories into a practical model that can guide planners to improve plan quality in the planning process. At the end of this paper, the conclusion section, two research questions will be answered and limitations will be stated.

Section 6.1: Discussion

The following are core findings based on the results chapter above.

(1) Overall, the sample cities in U.S. have established a low-carbon city planning framework in their current comprehensive plans; however, they fail to incorporate specific low-carbon city principles into their frameworks

effectively. The results indicate that the sample plans are strongest in coordinating at multiple level organizations (M=8.53); slightly weaker in presenting implementation and monitoring (M=7.02); relatively weaker in stating factual basis (M=5.73) and policies, tools and strategies (M=5.51); and weakest in setting goals and objectives (M=5.30). The mean scores of all five components are above 5, inferring that cities provide a good foundation for achieving low-carbon city planning. However, some carbon- related indicators have not been converted entirely into low-carbon city principles in local comprehensive plans. The following are detailed findings for each component.

(2) The local plans in the sample identify the general factual basis of low-carbon city planning, such as population change and impacts, land development and sphere of influence, and an inventory of existing resources and energy usage. These indicators are fundamental issues stated in most plans. That is the reason why most of them received high coverage scores. However, they lack details to address issues associated with low-carbon city planning, which explains the relatively lower depth scores. For example, only four sample comprehensive plans do not contain population changes and impacts issue information, but 22 of them, less than half, provide a detailed inventory of population change related to climate change. Meanwhile, the majority of cities' plans also provide adequate knowledge of ozone layer depletion because EPA has set National Ambient Air Quality Standards (NAAQS) from 1997 required by Clean Air Act. However, there are still 14 cities that do not mention ozone

layer depletion at all. The other two indicators, climate change impacts and vulnerability and recognition of greenhouse gas (CO_2) emissions, which are directly related to low-carbon planning, fail to be addressed in more than half of the sample plans.

(3) Goals and objectives received the lowest scores among the five components. Generally speaking, sample plans included broad notions supporting low carbon planning, but lack clear goals to implement effective low-carbon city policies. For example, promoting a compact and multicenter urban form is a traditional urban planning goal receiving a high coverage score (88%) and depth score (78%); however, the city carbon emission reduction target is vague and unfocused (coverage score 36%; depth score 29%). Moreover, only 50% of plans mention the uncertainty indicator, and among them, only 11 cities (depth score is 29%) includes detailed information. This finding indicates that cities do not have clear long-term goals to address climate change. Similarly, more than half of cities (66%) require equity assistance and environmental justice, but only 14 out of 50 cities (47% depth score) are focused in their intent. The best performance is the indicator of seeking energy conservation and energy efficiency, which infers that cities have highlighted some low-carbon planning goals already.

(4) The coordination within and beyond cities and organizational boundaries is strong and is reflected in the highest scores of the five components. Only two sample cities fail to address coordinating with surrounding jurisdictions, while

five cities do not contain public education programs and environmental stewardship. Those cities also received very low total quality scores. Nevertheless, this may be due to requirements by state and federal laws.

(5) Policies, tools and strategies focus primarily on traditional tools and regulations. Most sample cities provide adequate policies, tools and strategies on urbanization development and transportation system, especially urban development tools, and thus increase the quality score of their plans. For the energy system indicator, the majority of cities provide general information, and this result is consistent with the results of the goals and objectives component. However, some innovative indicators like green infrastructure systems or establishing a cap and trade system/ carbon tax are not widely used. Planners and policy makers must expand their toolbox to achieve the low-carbon city effectively.

(6) The implementation and monitoring component received the second highest scores. Most plans have clear schedules for implementing policies, tools and strategies and monitoring and review of task performance regularly. The only problem in this component is that plans need to fully describe roles and responsibilities in sustainability among sectors and stakeholders.

The findings from the results of this study point out how and where low-carbon city planning issues can be adopted into local land use decisions. These findings also provide a guideline for planners on how to prepare future low-carbon city plans. The following are planning recommendations generated from the results and findings

above. They may give a direction to planners on how to achieve low-carbon goals from a bottom-up perspective while promoting low-carbon city planning approaches to development.

(1) *Improving knowledge of low-carbon city and climate change*: The most important step in raising the overall quality score of a comprehensive plan is to improve its factual basis by providing more and through knowledge of the low-carbon city and climate change. In the results presented above, climate change impacts and GHG emission indicators rank as the relatively lower scores in the factual basis component in terms of plan preparers lacking adequate understanding of potential severe impacts and motivation to include low-carbon city principles into their plans. An excellent low-carbon factual basis should contain information on what climate change impacts are, vulnerability issues, and why these problems should be addressed. The lack of adequate information could cause planners and decision makers to underestimate the impacts and consequences. Not only is it important to educate the general public and planning participants to be acquainted with low-carbon principles, but it is also necessary to help planners and stakeholders increase their motivation to adopt these principles into their local land use planning instruments, especially the comprehensive plan. Efforts to build a low-carbon city become more proactive when planners and stakeholders act because they want to, not because they have to (Brody, 2003).

(2) *Adopting more specific carbon goals and policies*: As previously mentioned,

the goals and objectives rank as the lowest scoring component and leaves the most room for improvement in the future planning process. The major weakness found in this research is that sample plans lack clear and specific low-carbon goals and policies. Based on the results, a city's comprehensive plan needs to include clearer and more detailed goals to guide the implementation of low-carbon city initiatives. Such goals usually include accompanying timelines that show when the goals must be accomplished (Brody, 2003) and action priorities to address different issues. For example, plans should describe city carbon emission reduction targets clearly by identifying long-term reduction targets with short- and medium-term goals at multiple levels. Since federal and most states require that current climate change studies should coordinate at regional, national, or global levels, local jurisdictions need to incorporate it within their low-carbon city plans.

(3) *Expanding the planners' toolbox*: The findings above explore current plans and primarily emphasize a narrow set of policies, tools, and strategies, such as urban development tools or transportation system regulations. Local jurisdictions need more innovative policies, tools, and strategies to respond to climate change impacts and issues. Some traditional policies, such as mixed use, infill development, or multi-modal transportation corridor improvements can reduce local carbon footprint, but they are not enough to mitigate and adapt climate change impacts directly and effectively. Compared with traditional policies, some new tools (like green infrastructure systems, low

impact development, and cap and trade/carbon tax), need more attention which can be more effective in achieving low-carbon city goals. More importantly, such policies, tools and strategies encourage the mitigation and adaptation of climate change impacts at multiple spatial levels directly.

Section 6.2: Theoretical and Policy-making Contributions

The first contribution of this thesis to planning theory and practice is that it has extended the theoretical concept of the low-carbon city by integrating climate change (which is rarely covered in current local level planning decision making) into local land use plans. The intellectual merit of the research is based on advancing the understanding of the linkages between climate change and local land use planning capacity, and how to adapt policy mechanisms to mitigate and address climate change at a local level. Another expansion of the existing literature is that the research has identified fundamental principles of low-carbon city as the basis of the low-carbon city land use planning model. Those principles can be used to identify a clear definition of the low-carbon city in the future.

Second, this study makes significant contributions to planning theories by taking the broad theoretical principles of rationalism and converting them into a model showing how to actually achieve planning objectives that address climate change. Specifically, it provides a conceptual model, supported by specific indicators, to guide local jurisdictional development of plans to address climate change mitigation and

adaptation in practical planning processes. Moreover, the findings and improvement tools shed insight on how cities can incorporate low-carbon city planning approaches into their local comprehensive plans. The research further makes important methodological contributions to improve local policy making in a long-term, challenging, uncertain planning issue - climate change.

Finally, this study also has important broader impacts for local land use planners interested in building low-carbon cities to mitigate the adverse impacts of climate change. By understanding the areas in which their plans are deficient, policy makers can more effectively improve their planning capacity for addressing climate change. Specifically, local land use plans can be improved to address climate change through awareness, analysis, and action. Results contribute to a decision-making framework for climate change mitigation and adaptation by increasing the understanding of local land use planning capacity and carbon footprints. This study can provide guidance for land use planners to manage adaptively over time. This understanding is critical given the continued development of land and the increasing vulnerability of human populations to climate change.

Section 6.3: Conclusions

The results and findings above address the two research questions raised in Chapter One. The first research question: (1) how well do the fastest growing cities in U.S. implement low-carbon principles in their local comprehensive land use plans?

The results and findings indicate that the majority of top 50 fastest population growing cities in the U.S. have already established their comprehensive low-carbon city framework but have failed to adopt specific low-carbon city principles into their frameworks. The answer of the first question causes the second question to be straightforward: how can local land use plans be improved to achieve the goal of low-carbon cities? The results and findings show that cities must improve knowledge of the low-carbon city concept and climate change, adopt more specific carbon goals and policies, and expand the planners' toolbox to mitigate and adapt to climate change. Moreover, an integrated approach is necessary to combine them together with local land use decisions.

In sum, this thesis identifies fundamental principles of the low-carbon city derived from various literature and developed a conceptual model for low-carbon city land use planning. Then it converts principles and the model into the content of a local comprehensive plan by using the Five Component Protocol. Next, it identifies the top fifty population growing cities in U.S. as an ideal sample of cities to empirically examine the low-carbon city conceptual model. By evaluating their comprehensive plans quantitatively, the results show strengths and weaknesses of the capability of cities to achieve a low-carbon city. Finally, findings from the results and some plan recommendations are given, which may assist planners, stakeholders and decision makers to build a low carbon city for their citizens.

This study is one of the first studies to evaluate low-carbon city planning quality by using plan evaluation techniques. Therefore, although this research provides some

insight into how cities can achieve a low-carbon city in their local plans, it has some limitations. The most obvious one is the relatively small sample size (n=50) that may cause inadequate statistical power required to draw stronger statistical conclusions for the investigation (Brody, 2003; Tang et al., 2008). Moreover, samples are from fastest growing population cities from 2000 to 2004, which could reduce reliable or precise estimates when applying the results to other cities. Future research could identify another group or more to compare characteristics in order to obtain more precise estimates. For example, one could choose the top 50 fastest population growing cities in terms of percentage increase of population or the top 50 fastest population growing counties in the same period and compare them statistically. Or one could use a different evaluation protocol to explore the differences.

The second limitation of this research is involving subjectivity in the evaluation method. Although it is well accepted that the five component protocol provides the basis of measurement of local plans quantitatively, the assessment process is still subjective. This study repeats the rating process three times for each indicator and scans each plan three times to increase reliability of the scores, but it is impossible to avoid the researcher's personal bias completely. However, previous research found that this evaluation method received reliability assessment scores about 80-97% (Edwards and Haines, 2007; Tang et al., 2011), which indicates that the results of this study are unlikely to change even though there is certain unreliable evaluation in the coding process. Future study can use both internal consistency reliability and interrater reliability together to increase preciseness. For example, plans can be

reviewed by several other people several times and researches can use a weighted average to avoid subjective judgments. The concern of such evaluation method is time and cost.

The last limitation of this research is in the indicator measurement procedure. In the first stage, this study assumes all indicators are the same weight and each indicator score is ranging from 0-2. This is a reasonable, but simple, procedure to assess five components and their indicators. Actually, it works for factual basis, goals and objectives, and inter-organization coordination components assessment, but might be limited in the measurement of the policies, tools and strategies component and implementation component. For the policies component, there are total of 17 indicators in six categories, which may suggest that one category should be considered more important than the others. Future research could involve the design and use of a questionnaire survey or follow-up phone interview to explore the different factors that influence local plans for the carbon problem. For example, in the implementation and monitoring component, some implementation procedures may be found only in local ordinance documents rather than in the city comprehensive plans. Therefore, the components scores could be higher.

Future research should examine other variables that might affect low-carbon city planning quality scores, like contextual variables (including plan age, plan type, community residents' income, and education, and so on). It also should examine the external influence factors, like state statutory requirements for comprehensive plans,

current planning challenges and climate change information used, related to local plans in how to address the carbon issue.

The call for building low-carbon cities has become obvious nowadays, which has encouraged planners and policy makers to rethink their objectives, methods, and tools. The challenge of achieving a low-carbon city requires finding a balance between harmony with natural systems, human health, spiritual well-being and renewal, livable built environments, and fair-share community. Although the low-carbon city model developed in this thesis seems more sustainable theoretically than it is in practice currently, it is believed that some high-carbon development patterns of the past can be avoided in the future. Furthermore, each city has its own characteristics, which may lead to focusing on different problems. Therefore, the goal for a city to achieve low-carbon development is to find appropriate approaches and take immediate action.

APPENDICES

Appendix A:
The Top 50 Fastest Growing Population Cities in U.S. (Cities ranked 1 to 50):

Rank	City	State	Growth since 2000 to 2004
1	Los Angeles	CA	125,131
2	New York	NY	77,464
3	San Antonio	TX	70,079
4	Phoenix	AZ	67,371
5	Houston	TX	56,059
6	Fort Worth	TX	50,428
7	Charlotte	NC	43,830
8	San Diego	CA	43,353
9	Raleigh	NC	40,709
10	Henderson	NV	39,471
11	Las Vegas	NV	38,583
12	Sacramento	CA	38,317
13	Jacksonville	FL	38,164
14	Mesa	AZ	36,001
15	Gilbert town	AZ	35,553
16	Chandler	AZ	34,718
17	North Las Vegas	NV	29,014
18	Stockton	CA	27,695
19	Irvine	CA	27,489
20	Riverside	CA	26,348
21	Chula Vista	CA	25,504
22	Bakersfield	CA	23,978
23	Rancho Cucamonga	CA	23,897
24	Fresno	CA	23,803
25	Albuquerque	NM	23,249
26	Fontana	CA	22,974
27	Arlington	TX	22,038
28	Tucson	AZ	20,959
29	Laredo	TX	20,912
30	El Paso	TX	20,451
31	Plano	TX	19,961

32	Dallas	TX	19,738
33	Peoria	AZ	19,216
34	Aurora	IL	19,194
35	Modesto	CA	18,016
36	Corona	CA	17,488
37	Joliet	IL	17,349
38	Oklahoma	OK	17,171
39	Columbus	OH	16,962
40	Brownsville	TX	16,456
41	Cape Coral	FL	16,451
42	Austin	TX	15,449
43	Scottsdale	AZ	15,284
44	Moreno Valley	CA	14,682
45	Miami	FL	14,345
46	Omaha	NE	14,260
47	Virginia Beach	VA	14,210
48	Tampa	FL	14,200
49	Glendale	AZ	14,026
50	Aurora	CO	14,025

Notes: The city ranking data is cities shown on the City Mayors website based on the results of 2000 census data and the 2004 survey by the U.S. Census Bureau.

Source: http://www.citymayors.com/gratis/uscities_growth.html [Accessed March 2010]

Appendix B:
Sample Cities' Plans Information:

Rank	City	Plan Name	Adopted Year	Source Link
1	Los Angeles	Los Angeles City General Plan	2002	http://cityplanning.lacity.org/
2	New York	PlaNYC-A greener, greater new york	2011	http://www.nyc.gov/html/planyc2030/html/theplan/the-plan.shtml
3	San Antonio	San Antonio Master Plan Policies	1997	http://www.sanantonio.gov/planning/master_plan_comprehensive.asp
4	Phoenix	Phoenix General Plan	2002	http://phoenix.gov/planning/gpindex.html
5	Houston	City of Houston Comprehensive Plan	1999	http://www.houstontx.gov/planning/_GeneralPlan/cohPlans.html
6	Fort Worth	2010 Comprehensive Plan for the City of Fort Worth, Texas	2010	http://fortworthtexas.gov/comprehensiveplan/
7	Charlotte	Planning for Our Future	1997	http://charmeck.org/city/charlotte/planning/AreaPlanning/Plans/2015Plan/Documents/2015Plan.pdf
8	San Diego	City of San Diego General Plan	2008	http://www.sandiego.gov/planning/genplan/#genplan
9	Raleigh	The 2030 Comprehensive Plan for the City of Raleigh	2009	http://www.raleighnc.gov/business/content/PlanLongRange/Articles/2030ComprehensivePlan.html
10	Henderson	City of Henderson Comprehensive Plan	2006	http://www.cityofhenderson.com/community_development/comprehensive_plan.php
11	Las Vegas	Las Vegas Master Plan 2020	2000	www.lasvegasnevada.gov/files/LV2020MasterPlan.pdf
12	Sacramento	Sacramento 2030 General Plan	2009	http://www.sacgp.org/

13	Jacksonville	City of Jacksonville 2030 Comprehensive Plan	2010	http://www.coj.net/Departments/Planning-and-Development/Current-Planning-Division/2030-Comprehensive-Plan.aspx
14	Mesa	City of Mesa General Plan	2002	http://www.mesaaz.gov/planning/PDF/GeneralPlan/MesaGeneralPlan.pdf
15	Gilbert town	Gilbert General Plan	2010	http://www.gilbertaz.gov/generalplan/default.cfm
16	Chandler	City of Chandler General Plan 2008	2008	http://chandleraz.gov/default.aspx?pageid=121
17	North Las Vegas	City of North Las Vegas Comprehensive Master Plan	2006	http://www.cityofnorthlasvegas.com/Departments/CommunityDevelopment/2006ComprehensiveMasterPlanDocument.shtm
18	Stockton	Stockton General Plan 2035	2007	http://www.stocktongov.com/government/departments/communityDevelop/cdPlanGen.htmlStockton,CA/cdPlanGen.html
19	Irvine	The City of Irvine General Plan	1999	http://www.cityofirvine.org/cityhall/cd/planningactivities/general_plan/default.asp
20	Riverside	Riverside General Plan 2025	2009	http://www.riversideca.gov/planning/gp2025program/general-plan.asp
21	Chula Vista	Chula Vista Vision 2020	2005	http://www.chulavistaca.gov/City_Services/Development_Services/Planning_Building/General_Plan/documents.asp
22	Bakersfield	Metropolitan Bakersfield General Plan	2007	http://www.bakersfieldvision2020.com/index.php
23	Rancho Cucamonga	Rancho Cucamonga General Plan	2010	http://www.cityofrc.us/cityhall/planning/genplan.asp
24	Fresno	2025 Fresno General Plan	2002	http://www.fresno.gov/Government/DepartmentDirectory/PlanningandDevelopment/Planning/2025FresnoGene

				ralPlan.htm
25	Albuquerque	Albuquerque/Bernalillo County Comprehensive Plan	2003	http://www.cabq.gov/council/documents/abq_comp_plan.pdf/view
26	Fontana	City of Fontana General Plan	2003	http://www.fontana.org/index.aspx?NID=813
27	Arlington	Arlington 2025	2003	http://www.arlingtontx.gov/planning/arlington2025.html
28	Tucson	City of Tucson General Plan	2001	http://cms3.tucsonaz.gov/planning/plans/genplan/
29	Laredo	Comprehensive Plan of Laredo, Texas	1991	http://www.ci.laredo.tx.us/city-planning/Books_and_Manuals/Comprehensive_Plan.pdf
30	El Paso	The Plan for El Paso	1999	http://www.elpasotexas.gov/econdev/plans_studies_maps.asp
31	Plano	City of Plano Comprehensive Plan	2004	http://www.plano.gov/Departments/Planning/planningdocuments/Pages/ComprehensivePlan.aspx
32	Dallas	forwardDallas! -Comprehensive plan Vision	2006	http://www.dallascityhall.com/forwardDallas/index.html
33	Peoria	Peoria General Plan	2001	http://www.peoriaaz.gov/content2.asp?id=25810
34	Aurora	Countryside Vision Plan	1984	http://www.aurora-il.org/development_services/planning_and_zoning/comprehensive_plan.php
35	Modesto	City of Modesto Final Urban Area General Plan	2008	http://www.modestogov.com/ced/documents/planning_general-plan-meir.asp
36	Corona	City of Corona General Plan	2004	http://www.discovercorona.com/CityOfCorona/media/Media/CommunityDevelopment/GeneralPlan/GenPlan.pdf
37	Joliet	Joliet Quality of Life Plan	2007	http://www.cityofjoliet.info/documents/FullText11-05-0

				7_000.pdf
38	Oklahoma	OKC Plan, 2000-2020	2000	http://www.okc.gov/planning/documents/OKCPlan2000-2020.pdf
39	Columbus	Columbus Comprehensive Plan	1993	http://development.columbus.gov/uploadedFiles/Development/Planning_Division/Document_Library/Plans_and_Overlays_Imported_Content/complan.pdf
40	Brownsville	Imagine Brownsville! A Call to Action	2009	http://www.imaginebrownsville.com/draftplan.php
41	Cape Coral	Comprehensive Plan	2010	http://www.capecoral.net/en-us/government/projectandbuildinginformation/planningandgrowthmanagementdivision/comprehensiveplanning/comprehensiveplangoalsobjectivespolicies.aspx
42	Austin	Austin Tomorrow Comprehensive Plan	1980	http://www.ci.austin.tx.us/AustinCityConnection.htm
43	Scottsdale	City of Scottsdale General Plan 2001	2001	http://www.scottsdaleaz.gov/generalplan/generalplan2001
44	Moreno Valley	City of Moreno Valley General Plan	2006	http://www.moreno-valley.ca.us/city_hall/general_plan.shtml
45	Miami	Miami Comprehensive Neighborhood Plan	2010	http://www.miamigov.com/Planning/pages/community_planning/CommunityPlanning.asp
46	Omaha	Omaha Master Plan	2009	http://www.cityofomaha.org/planning/urbanplanning/omaha-master-plan
47	Virginia Beach	City of Virginia Beach Comprehensive Plan	2009	http://www.ourfuturevb.com/compplandocs/Pages/default.aspx
48	Tampa	City of Tampa comprehensive plan	2005	http://www.theplanningcommission.org/tampa

49	Glendale	Glendale 2025 The Next Step General Plan	2002	http://www.glendaleaz.com/planning/generalplan.cfm
50	Aurora	City of Aurora 2009 Comprehensive Plan	2009	https://www.auroragov.org/AuroraGov/Departments/PlanningAndDevelopmentServices/ComprehensivePlanningDivision/PlansAndStudies/ComprehensivePlan/2009ComprehensivePlan/index.htm

Appendix C:
Raw Scores for Plan Components and Total Scores:
(Raw scores are used to convert to standardized score in Section 5.1)

Rank	City	State	Factual basis	Goals and objectives	Inter-organizational coordination	Policies, tools and Strategies	Implementation and monitoring	Total
1	Los Angeles	CA	8	8	6	16	7	45
2	New York	NY	10	9	6	24	6	55
3	San Antonio	TX	4	3	6	20	4	37
4	Phoenix	AZ	10	8	5	21	5	49
5	Houston	TX	5	2	3	7	4	21
6	Fort Worth	TX	8	8	5	24	6	51
7	Charlotte	NC	5	3	4	17	5	34
8	San Diego	CA	11	9	5	25	7	57
9	Raleigh	NC	11	9	6	30	8	64
10	Henderson	NV	5	3	5	11	5	29
11	Las Vegas	NV	10	7	6	25	8	56
12	Sacramento	CA	11	9	6	29	7	62
13	Jacksonville	FL	9	5	6	22	6	48
14	Mesa	AZ	6	4	5	13	3	31
15	Gilbert town	AZ	9	5	5	16	5	40
16	Chandler	AZ	5	4	5	19	5	38
17	North Las Vegas	NV	5	6	5	13	5	34
18	Stockton	CA	11	9	6	24	6	56
19	Irvine	CA	3	4	5	16	2	30
20	Riverside	CA	12	9	6	20	7	54
21	Chula Vista	CA	9	7	6	23	5	50
22	Bakersfield	CA	6	1	6	10	5	28
23	Rancho Cucamonga	CA	12	7	6	29	8	62
24	Fresno	CA	3	5	4	21	6	39
25	Albuquerque	NM	8	3	6	19	6	42
26	Fontana	CA	7	4	5	20	6	42
27	Arlington	TX	2	2	3	15	3	25
28	Tucson	AZ	6	5	6	15	6	38

29	Laredo	TX	3	3	5	8	3	22
30	El Paso	TX	7	5	6	20	5	43
31	Plano	TX	8	6	5	15	1	35
32	Dallas	TX	4	6	5	20	5	40
33	Peoria	AZ	7	4	6	28	7	52
34	Aurora	IL	1	4	2	13	2	22
35	Modesto	CA	6	5	4	22	5	42
36	Corona	CA	8	3	4	17	6	38
37	Joliet	IL	4	2	3	15	8	32
38	Oklahoma	OK	5	4	4	12	5	30
39	Columbus	OH	3	3	5	10	6	27
40	Brownsville	TX	7	7	6	23	7	50
41	Cape Coral	FL	3	4	5	15	4	31
42	Austin	TX	6	6	6	19	8	45
43	Scottsdale	AZ	5	4	5	20	8	42
44	Moreno Valley	CA	8	6	5	10	6	35
45	Miami	FL	2	3	6	12	7	30
46	Omaha	NE	11	9	6	26	8	60
47	Virginia Beach	VA	11	6	5	22	3	47
48	Tampa	FL	7	5	6	25	7	50
49	Glendale	AZ	7	4	5	17	7	40
50	Aurora	CO	10	8	4	25	7	54

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